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Three conference papers concerned with systems analysis and time management planning. One paper is concerned with techniques, especially the application of the "critical path method" or PERT (Program Evaluation Review Technique) in planning construction activities. A second paper concerns problems associated with collecting and communicating knowledge about educational facilities. A third paper discusses the advantages of time management techniques in program planning. Also included is a discussion centered about an application of time management planning. (FPO)

TIME-MANAGEMENT PLANNING

FOR EDUCATIONAL FACILITIES

TIME-MANAGEMENT PLANNING FOR EDUCATIONAL FACILITIES

By

Professor Donald N. McIsaac
The University of Wisconsin

Professor Stewart D. North
The University of Wisconsin

Professor Howard E. Wakefield
The University of Wisconsin

ERIC Clearinghouse on Educational Facilities
The University of Wisconsin
Madison, Wisconsin

March, 1969

FOREWORD

An invitational conference was held in early July, 1968 at the University of Wisconsin. The theme of the conference was Environment For Learning.

These papers were presented during the conference. The transcription of that presentation is contained herein. It is a statement which will bo of value to educational leaders, design specialists, and students of the subject.

The ERIC Clearinghouse on Educational Facilities (ERIC/CEF) was a sponsor of the conference, as were several educational associations and agencies. ERIC/CEF is a clearinghouse of information about sites, buildings, and equipment used for educational purposes; included are the efficiency and effectiveness of activities such as planning, financing, constructing, renovating, maintaining, operating, utilizing, and evaluating educational facilities.

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Howard E. Wakefield,
Director

March, 1969

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Note: Pagination - as this is one part of conference proceedings, pages 1-25 are not included. Pages should be 26 through 56.

TIME MANAGEMENT TECHNIQUES FOR PLANNING THE ENVIRONMENT FOR LEARNING

Dr. Donald N. McIsaac, Jr.
Department of Educational Administration
The University of Wisconsin

I spent a great deal of time working with technical aspects of computers--input, output, programs--and so as a consequence I have to spend a good deal of my time convincing my colleagues that there is the human side to my character.

In order to demonstrate this to you, I have a couple of stories about computers that I'd like to introduce. Possibly you may have heard them, but this first one deals with the first computer installation for the Department of the Army. They felt that this was really quite a sophisticated machine capable of decision analysis for virtually any probability. This was introduced to the old general who was used to doing things in the old way. He was a little bit skeptical, but the technicians pointed out to him that this was really a very well programmed computer and had, in fact, most of the answers which he might be seeking. "Will there be a third world war and what will the nature of that war be?" The computer hummed away for a minute or two and made a few clicks, noises, the lights flashed, and it came back with,"Yes."

He looked at the machine and said, "That is a totally inappropriate answer. It does not give me enough information to make any further decisions. Yes, what?" To which the computer replied, "Yes, sir."

Well, the general was very put off at that kind of response and he said, "That's not only an inefficient machine, it is also impertinent. I do not believe in this kind of technology."

The technicians said, "Well, possibly, you would like to ask a question in another area. The computer is well programmed and can answer virtually anything." The general said, "Well, where is my father?" The computer responded, "Your father is on the end of the Santa Monica pier fishing." The general chuckled and said, "Well, that just goes to prove that the computer really isn't as efficient as you say, because my father died five years ago." The technicians said, "Well possibly you would like to rephrase your question slightly, because it is well programmed." So he said, "Okay, I will try one more time." He said, "Where is my mother's husband?" The computer hummed for a minute and said, "Your mother's husband died five years ago. Your father is still on the end of the Santa Monica pier fishing."

As we face the problem of time management I am reminded of Churchill at the time he was invited to address the Temperance Group in England. He was a little curious as to why he would be invited to make any kind of presentation to such a group. He thought he would attend if for no other reason than to find the answer to that question. He listened, and he heard his introduction which went something like this.

"Mr. Churchill, you may wonder why you have been invited to attend this group, but we would like to point out that our statisticians have computed and figure you have consumed sufficient spirits in your lifetime to fill this vast chamber to the level of your eyes."

That was his introduction, and he got up and thought for a minute and said that he was very interested in the fact that their statisticians had computed, whether accurately or inaccurately, that he had consumed sufficient spirits to fill this vast chamber to the level of his eyes. He could only remark as he gazed toward the ceiling, "There was so much to do and so little time in which to do it."

I think that may be something of the feeling we have sometimes when we face the problems of generating educational programs and building schools which is the topic I am going to discuss with you briefly this morning. Let me say that the time-management techniques I wish to outline with you very briefly are referred to as The Critical Path Method. The differences between PERT and Critical Path Method are very subtle, and I do not think chat I will go into those, as for all practical purposes they appear identical. The only apparent difference is that for any activity duration time, you make three estimates for a PERT approach and you only make one for a Critical Path approach. But that is getting a little bit ahead of the story.

I think that as we look at the problems in constructing a school or establishing an educational program, we are faced with a project of considerable magnitude. It also is the kind of a project which is sensitive to a systems approach. It is possible to break down such a project into its various small activities which lead to the completion of the project. I have here a very brief graphic summary of the activities necessary for creating this kind of a systems approach to the establishment of a school program or the construction of a physical facility.

The first box indicates the necessity for identifying activities. In the construction of a school there are a great many processes that go on. It is necessary to identify each of these activities, isolate them, and determine what must go into that particular process. Each activity must be assigned to some individual or group of individuals.

First, each responsible individual or group estimates the duration of each activity. In other words, one must decide how long each small part of a total given project will require. Second, the layout of interrelationships of all of the activities together is presented. In other words, a graphic network is displayed of the entire project. Following this step is an initial computer run after which review and corrections are made, and then a system of periodic review must be established. This is a general, rather brief, commentary on the remarks that I will be making. The general outline of my discussion also, coincidentally, happens to be a general outline for an approach to the solution of a Critical Path, PERT, or time management problem in the generation of an educational program or in the construction of a school.

The first step involves the identification of those activities that might go into the completion of the project. This particular list of activities is drawn from a sample school district in Illinois which is in the process of creating a new middle school. This is a rather selective sample of activities which might be involved in that project. You will notice that these do not involve the physical construction, but rather the development of the educational program.

These are time-management lists of activities which include selection of the principal, preparation of a public information program, determination of school boundaries, planning of administrative organization, organization of the curriculum study, scheduling the busses and selecting department heads, and administrative staff. I think you can recognize from this kind of a list of activities that we are generating an educational program for this middle school and have identified small activity components of the entire project. Following the original outline, the second step in the process involves the assignment of responsibility.

Responsibility in this case is assigned on the basis of a coded number. The responsibility list is in the column to the left. Another school district approaching the same problem would not necessarily have the same list of activities. Nor would it be necessary for them to make the same distribution of assignment of responsibility to which we see here.

I think you can see that two key administrative components are a part of this process. Number one: the individual components of the project are identified and will be outlined. Two: the individuals responsible for the completion of those activities are identified.

You will notice that the third step is the determination of the activity duration. It is essential that determination of duration follow the assignment of responsibility, because the individual responsible for a given activity should provide its duration estimate. It is not reasonable that one individual sit down with the entire list of activities, assign responsibilities, and also determine their duration. I think you can see that if one were to sum total the column on the right, this would be a representation of the amount of time it would take to satisfy all of these activities were they done one right after the other.

The next step in the process is to take this list or a similar list of activities, together with their durations and responsibilities, and generate a graphic display of these interrelationships. This is generally referred to as a "network". The way one generates this network is to identify an activity. For instance, the first activity was the selection of the principal. One merely draws a line with an arrowhead on it. The symbol with an arrow signifies an activity. An activity is that which consumes either time and/or resources, generally both.

The circles you note here are referred to as events. An event is a point in time which signals the beginning or end of an activity or activities. It is a point in time which consumes neither time nor resources. Following those basic rules of this graphic display, one says that during the first activity nothing else can be done, and, moreover that activity is independent

of any other activity. Nothing else can occur at the same time. The second activity follows the same rule. After the second activity, it is possible to begin four things at the same time. These four activities comprise the selection of the principal (the preparation of the public information program could not begin until the selection of the principal was determined), the determination of the school boundaries, the plan of the administrative organization and the organization for curriculum study. These four things may all occur simultaneously following the preparation of some public information program.

You recognize this is one staff's interpretation of how these activities might be related. It is not necessary that they be oriented that way. Different groups will take different approaches. Nevertheless, this is how the interrelationships as defined by this group of educators portray themselves in the network.

You will notice that there are some dotted lines also on this graph and this is representative of those situations where the activity leading from event number 275 cannot be completed until the activity leading to 275 has been satisfied. There is no logical activity or specific activity that goes from 175 to 275 but all of these activities leading from 275 are dependent upon the satisfactory completion of these activities here. One demonstrates this by drawing in the dotted line activities which are referred to as dummies or constraints.

Therefore, this is a map of the interrelationships of all of the activities that go into the completion of a given project. Incidently, as one approaches the list of activities and begins to lay out their interrelationships, it is not necessary to have numbers within these events. As a matter of fact, you just begin drawing and demonstrating the interrelationships. The numbers are necessary for the computer solution. The only rule is that the number of a preceding event for an activity must be smaller than or less than the number that represents the succeeding event. This is necessary for the inherent logic of the computer solution.

What have we done up to this point? We have identified the objectives of the project. Second, we identified the individual activities that go into that project. Third, we have assigned responsibility. Fourth, we have assigned a duration estimate of how long each of these activities will take. And fifth, we have identified their interrelationships and how these activities go together.

I think you will admit that this is no small task. It takes considerable thought to identify the activities and demonstrate their interconnections. But once that job is done, you can appreciate the kind of possible review.

At the same time, you also have the opportunity to make some sort of mathematical estimates for scheduling specific activities, and this is where the computer can be useful. I think that although it may be a little difficult to read, I will review a computer project out with you.

You will notice that the same list of activities appears in this list. The list of activities identifies the initial phase; selection of the principal, the preparation of a public information, determination of school boundaries, planning of the administrative organization, etc. This is the list of activities which we began to work with. It contains the responsibility code so we have represented here the assignment of responsibility.

In this column we have the estimated duration of each of these activities. Once the network was established, numbers were assigned to each of the codes or events within that network and these are represented in two columns. Each activity obviously has a preceding event number, a succeeding event number, and both are listed for this output. The left side of this page represents the kind of input that would go into this kind of computer problem. It represents the kind of information that a very sophisticated planner might do intuitively. The manager of a construction job probably has a lot of this kind of information in his head. As projects get increasingly complex, it gets increasingly difficult to keep all of this information in one place and call it out readily.

What does the solution provide? Without going into the mathematical derivations, the solution includes a potential schedule for the satisfactory completion of this kind of a project.

Turning back just for a brief minute to this network, you can appreciate the fact that there is a duration, a time estimate, associated with this activity. Obviously, from the way the network is established, the second activity, 20-100, cannot begin until the first activity is completed. Activities 100-250, 100-150, and 100-200 cannot begin until the activities leading to those have been completed. Using that as the conceptual base for the solution of this network, adding all of the activities across this way, and subtracting their duration this way, one arrives at the earliest start for each of the activities and the latest finish for each of these activities. Now taking the latest finish and subtract the duration, one arrives at the latest possible finish. That is the general way in which these columns, the early-start, early-finish, late-start, and late-finish are computed.

Obviously, if an activity does not have any difference between the earliest finish and the latest finish, it is a critical activity. I think that you may sense that if you were to add up the total duration of every possible path through this network, you would find one path that is the longest. That is the path that represents the amount of time (estimated time) it will take to satisfy the completion of this project. It is referred to as the Critical Path, because each one of the activities along that path must follow the prior activitiy with no delay. There is no opportunity for slack or free time within the critical path, because the summation of those durations equals the project completion. There are other activities or other paths through this network that represent less time. If the project cannot be completed until all of the activities are satisfied, then there are obviously some activities in the network that have free time or slack time.

The last three columns on this output represent estimates of slack or free times that occur. We have total slack which may be a cumulative kind of thing. For instance, if this path across the top has slack time in it and you use the free time that you have available from 1100 to 1550, then you do not have that same free time available for activity 1550 to 1700. In other words, there is a cumulation of slack across a given path. There are other kinds of slack. The notion of independent slack is slack that will not cause the delay of any other activity if you delay that period of time. For instance, we indicated that in this line, if 275 to 1100 has five days of slack time, you can delay that five days, and you won't delay the completion of the project. If you use five days here, you do not have it available somewhere else. However, in a situation such as this, (this has five days of slack and that has five days of slack) you may be able to use both slack times because of these two restraining activities that come in.

Without going into the further mathematics of the problem, these last columns represent estimates of slack time or that time you may delay an activity without delaying the completion of the project. This is the kind of outputed information which is made available to a planner using the Critical Path methodology. Together with a list of activities and a list of those activities that are critical, one has an information base on which to schedule whatever the project activities may be. This schedule, if not adhered to, will indicate the potential delay in the completion of the project, and may contain valuable information. For instance, on the project in Dubuque, Iowa, it became very evident that unless the school principal was appointed sometime before July 1, there were many activities which would not be satisfied when school opened on September 1st. The Superintendent admitted that the principal had to be appointed at an earlier date.

Basically that is the notion of the Critical Path Method and we have an opportunity for you to take part in this kind of method. What I have done is taken the network that we have just reviewed and have keypunched the information regarding each activity into the card. All that is required is your estimate of how long each of these activities will take. While Professor Wakefield is discussing additional with you, I will take these cards to the Computing Center, have them run and return with, hopefully, a hundred copies of each output so that you will have an opportunity to see how it works.

I would like to keep these in order if I can because the order is important.

COMMUNICATION BROBLEMS

Professor Stewart D. North
Department of Educational
Administration
The University of Wisconsin

Educators (and I quickly add with the aid of design specialists) have been trying to solve their educational problems over the years by shuffling standard boxes around. These boxes being the classroom, and this basic box is supported by a whole core of dogma; standard class size, five periods per day, given subject matter, traditional prodedures, and I would say somewhat archaic administrative practices. We make these plans to serve an average child that in most instances actually does not exist.

Certainly these problems that we are all very aware of exist in all areas of education but most significant to us in the area of planning and facilities. I guess that is because our mistakes live longer than those of the curriculum expert. They can just turn out another guide, the new approach to math or such, and people will have forgotten or lost their original guide. Mistakes or shortcomings in facilities seem to stand before us and haunt us year after year. We could find several good reasons, perhaps justifiable reasons, for the less than perfect results of our planning efforts. Let me then point out four to you.

First, the breadth and scope of the field of educational facilities is a basic problem. We are dealing with buildings, equipment, site, and so forth. The parameters of our concerns are not very clearly defined. We have not been able to accumulate a body of knowledge, put it on a shelf, and go to it when we are in trouble. The fact is simply that we must cut across many disciplines. The most significant, the most visible cross section or divergent view, is that on one side we have architects and on the other side we have educator types, and this causes concerns.

Second, the lack of an organized body of knowledge. I referred a moment ago to the fact that we do not have a body of knowledge as large, comprehensive, and sophisticated as we might wish. There are reasons for this. We did a little study on this with the help of Dr. Ross Papke and the cooperation of people in the State. We looked at the research (I use research and I do not mean it in the most sophisticated meaning) and available knowledge, how it was being generated, what portion of it was being supported by educators, and what portion was being supported by what I would call design specialists. We quickly found out that

on the side of design specialists research and investigation is not a very high status effort.

Third, there is little stimulus for research and development activities. Architects and design specialists become recognized and affluent by their works, designs, and buildings, and so there is no good reason why they should spend much time seeking out universal answers to our problems. Basically educators who are concerned with facilities have the same orientation. There are a few unique individuals located in universities and elsewhere who give some attention to research, but most educators who are involved in facilities are practitioners, persons concerned with day-to-day problems. They wish to solve their problems in their particular school district or university and are not concerned with universal answers.

Finally, one of our continuing problems is that we are really unwilling to determine, to point a finger at one group and say who is or should be the ultimate judge of the product. I am talking about educational facilities. Is the client the school-board? In other words, are they the ones who will judge its adequacy? They might judge it upon criteria that would not be satisfactory to another possible client which would be the staff and/or the students, the administration, teachers, etc. If that group is recognized as the client, to say whether it is good or bad, we would undoubtedly have a different standard. Also, there is the public. They are the owner in fact and will judge the product, maybe, on its dollar cost, or they might judge it on how it improves the aesthetics of the community or the total environment. Then there are the producers - the architect and contractor; they probably will have a different criteria.

We are not here to solve these big issues today. We are here to look at some tools which might be more helpful in the process of planning, designing, constructing, and maintaining facilities so that we can get a better product to live with. All of you are very conscious of the great emphasis that has recently been placed on management techniques and tools. You only need to look at the publications that have come across your desk on the systems approach, computer applications, program planning and budgeting, and so forth to know of the great emphasis here. Nonetheless, the evolution of the idea we are going to present grew out of pressures, mainly those which come from you. In our contact with the field, you kept telling us there must be better ways to do the planning that you must do.

We were fortunate to bring to our campus Professor McIsaac. His total concern is computer applications to educational administration. About the time Dr. McIsaac arrived on campus I came back from a chance to try to practice the trade of you administrators in our group. There was exposure to the government requirements for CPM and PERT both in the construction and programming in work with RCA.

We must find tools which permit the exercise of leadership by the person or persons held responsible. There must be a way that he can get his input, his ideas, his judgments, his concerns into the process before and during rather than after the fact. I got the feeling while struggling as a practitioner (I use the analogy because of an interest in flying) that if you sit at the head of a sizeable operation, it is like flying a 707 from the stewardess' jump seat, the last seat in the back, with rubber bands on the controls. In other words, by the time the plane reacts to input and you get feedback it is too late to do anything about the trouble you are in. This is a continual problem we face, and we see that this is particularly significant when we are dealing with program planning and facilities. The Critical Path Method or Program Evaluation and Review Technique may prove a useful tool in delineating the management problem.

If you look at this as a technique, it has been used in business and industry since about 1958. The government, as those of you in the architectural field who work with government contracts know, requires it for all government construction. School systems for the past four or five years have been playing with this technique as it relates to construction. There are pros and cons on its impact and value in this area. However, a majority of case studies indicate that there are more benefits than problems.

Yet, as we thought about the situation, we had the distinct feeling that as far as the design, construction, and those activities which create the facilities the design specialists were quite a way ahead of the educator in the planning process. Since it is within the family, educators can admit that if we get behind in the opening of a school and are squeezed for time, it is not unusual for the superintendent or the management, out of necessity, to cancel the orientation for the staff that is going into that building. The teachers go in cold rather than prepared. This is less obvious to the public than if the equipment is not ready on time. In other words, it seems to me that though we can get by by doing a less-than-adequate job in planning and programming on the educational side (and this is really the crux of the matter) it comes back to haunt us at a later date.

In a chance to develop this idea with several school systems, we took the activities that the school system identified as important on the planning side -- not the construction side, but on the planning side -- and put them into a CPM network. We were somewhat surprised to note that as we went through this process (and it is a process which you will go through in a workshop situation this morning) that educational programming took just about as much time as did construction programming. In Dubuque we found out that construction programming was about 409 working days, and the educational planning required something like 415.

We believe that this tool should be tried not only on the technical side but also on the educational side to see if it will help the leadership control their decisions with a bit more precision.

PROGRAM PLANNING

Professor Howard D. Wakefield
Department of Educational Administration
The University of Wisconsin

Dr. North and Dr. McIsaac have said about what needs to be said about the time-management plan. I was asked to say a few things about program planning generally and how this system might be helpful in that regard. Most of us realize what a big job program planning is, and we have all had reams of experience with it. What we do is usually intuitive. Either out of our own experience or with the help of other people on the staff we get the job done. Sometimes we wait until pressure or need arises to prompt us to do some of the things that need to be done.

The intuitive approach is inclined to follow topical lines. This is the way we are taught; it is the way courses are organized in the university; it is the way we do our job. If we take a course in staff personnel administration, we know there are certain personnel decisions which have to be made when program changes are made or program planning is being done. Certain people have to be picked out for a new role or new teaching assignments. We are disposed to think of such personnel decisions categorically. Sometimes we even assign them that way. We have administrative assistants, or department heads, or deputy superintendents, or assistant superintendents who perform these functions. We do the same thing with program matters. We either rely on a curriculum director or we think of this task categorically. There are decisions to be made along that line. It is the same way with materials and equipment.

The systems approach is a relatively new way of trying to systemitize the many program decisions which need to be made and which need to parallel construction activity. It has not often been done that way. There have been a few efforts made, mostly along some systems model approach such as the Philadelphia School System has tried out which is somewhat different from this time-management plan. The latter is aimed at creating a facility and doing the appropriate planning systematically which is required for that facility and for occupying it. The former is aimed at trying to get some notion of all of the dimensions of the whole system. We feel the time-management plan is a very promising idea; that's the reason we are engaged in trying it out in several places to see if it would not make the work of program planning much easier, go much more smoothly, and not be quite so hectic.

Of course, whenever new construction of some kind or a major program change is made in a school system, it presents us today with quite a few choices or alternatives, more than we have ever had before. In curricula, in certain fields such as mathematics and science, it is just like alphabet soup. You have quite a few things to consider. Whether you do it, whether some department heads do it, a system wide committee does it, or whether a director of curriculum does it, it still has to be done. Something has to be decided, and that has some effect on the facility that you may be planning and creating.

Many of these decisions become distractions unless they are systematized and put into the framework of a larger logic, some sort of time dimension which gives you a little bit more control over when things all fall together. It is not appropriate for some of these specialists in curriculum or in personnel to be the ones who manage and monitor the larger planning operation. It is your responsibility as superintendent, or if it is anybody else's, it would be a person who has some responsibility for research or for planning in your school system. The curriculum and personnel people have a role to play, as Dr.McIsaac pointed out. They have responsibilities which have to be carried out as part of this plan, but I am thinking of the overall plan and its administration - the time-management plan. It is essentially a top, administrative function, or one that should be assigned to a person in research and development or in your planning office.

I need not go into detailed descriptions. They are apparent in the list of planning activities that you see. I might make a point or two about that list. You will notice that it is not organized topically. The selection of a principal is not grouped with other personnel decisions. Each one of these activities is related only to one thing which is the time dimension or how long it takes to complete that particular activity and how important it is for that to precede some other activity which may or may not be the same type of decision logically. With that in mind you can take all of the things that you would normally think of under your program decisions, such as the desired consequences of what it is you are going to do in this new program, some of the organizational features of it, the course structure and content, instructional methods, and related services, and you can begin to put them all into the time-management plan.

It is the same way with your personnel decisions, selecting leaders, training them, and initially setting the qualifications that you want for some of these leadership posts. Finally, there are your material decisions, instructional supplies and equipment, the facilities themselves, and any public information decisions and events that might be associated with the creation of the new program and facility.

In summary, we see several important values to this system. One is that it provides crisis avoidance or at least a reduction

of crises that arise. In the second place, it does, we feel if properly administered, conserve time. It gives you the chance to complete more of the planning and make more of the decisions with less of the pressure and the added expense which is sometimes associated with pressure. It helps to avoid putting people on an overtime basis or putting them on at points in time when you have to pay them extra. It does have a crisis reduction feature, a time conservation feature, and, finally, it has a cost reduction feature. If you look at it on a per unit of output basis (whatever the output, quality, or productivity you may want to identify) you can effect savings if you maintain that unit of output as a constant guide. In the several minutes that remain before we take a break, we should give you an opportunity to raise some questions with Professor North and myself. Then, by the time that we are back from our break, we should have all of the computer printout back and ready to be looked at. Any questions?

Question: What measurement as related to size of project would you use to decide whether or not this method of management should be used?

Wakefield: If you are just going to change a course or make some minor changes of this type, I am not sure that that method is appropriate. Any major reorganization of your program or the creation of any new facility, whether it is an elementary school or a middle school or high school, does call for reconsideration of all these matters. If you create a second new high school in your community, you may decide to make it identical in program to the high school you now have. However, even that action calls for some time and attention and a decision of some kind that you have to make.

I would use this method with the construction of any new unit and in some cases with an addition if it is a substantial addition to the unit which calls for some reconsideration of the program which you are going to offer in that unit. I think the key to it is the extent of the program.

Question: . . . . . There are two areas that are bothering me. One is the assessment of the relationship of these critical events. Is it absolutely necessary to have activity 150 done before 200 begins? This is the first question I have.

The second question is I would think it would be no better than a man's guessing as to how long each one of these takes.

Dr. North: It is very obvious in construction that some events have to take place prior to the next. In other words, you can not hang a ceiling until you have some structure. It is equally obvious in our education plans, but we do not direct our attention to it. I would like to put your question in this form and say that it is not necessary that in Oshkosh one would set

up the sequence in the same manner that it might be done in Madison. However, it is rather essential that you determine a sequence and say, "Yes, in the real world, this is what it is."

Initial time allocation is by estimate. In other words, if you said, "If I have the responsibility for preparing the public information system, I would give you my best estimate of the necessary time." Then with the printout and the revision feature that we are going to talk about afterward, these times are refined.

It could be refined in two ways. One could look at the total operation as the chief executive and say, "My gosh, we have got to have this school by September 1st." So you call me up. "Stewart, are there ways that you could change? Is that a real estimate?" I would say, "Yes, it is my best guess at getting the job done in this manner." Then you might ask "Are there ways that you could do that more quickly?", and I might say, "Yes, give me an extra secretary."

Reallocation of resources might be a revision of plan. Time or estimates that you start with as you move down the line become refined, and as you go through the process some of the times in this revision are not estimates. They become what it actually took. Each time you revise this, whether it is bi-monthly or monthly, the length of the project duration will alter. You, as executive, would want to look up here and say, "Well our estimate was 409 days to get this done. We are now two months down the road, and each time we get a revised printout of this it is lengthening. That is bad. We have got to do something. We are not keeping up," or "Each time we are getting closer to our estimate." That is the value of the estimate. The initial estimate, I think, is critical principally as a planning tool, not critical upon meeting a deadline.

Question: Will Professor McIsaac's visuals be available for later digestion?

Dr. North: Yes, they will. You will have the printout on this. Our hope is that by going through this process, you will see the revision process. That is the important part of this operation, because as a chief executive or the one that is responsible for any operation (whether he is the architect responsible for the construction or whether you are a superintendent) you do not really have an opportunity to influence an activity when the decision that comes out of the activity is after or in a crisis situation. The only way that you can influence the total is to point to the person who was responsible for selecting a principal. You make his assignment and notify him. If you want to influence the type of person selected, you have to talk with me before I set up the specifications. The chief executive with this plan can look at what events are impending. He also can find out who is slowing down the machine, In other words, you can see that the guy who

is always behind is so and so.

There is no way of really beating a system under your estimates. If you do this, you might as well throw the estimate system away. The system is based on the assumption that you have integrity of personnel involved in it, and that it is a real plan. It is not something which you just show to the public and say, "This is the plan we are following." It is a plan which is modified day by day as we go along the project.

TIME MANAGEMENT PLANNING - AN APPLICATION
Dr. Donald N. McIsaac, Jr.

You fellows did not know it unless Stew told you in my absence, but we had green cards and orange cards. I think this side was the green side, and this side was the orange side. You will notice on the output it says orange team and green team. The orange fellows said it would take 381 days to finish the educational program for this school.

This is Ed McEnroe who will vouch for this big story that I just told you. Okay, let us pass these out here. Take one set which is a complete bit of information.

Dr. North:

Three hundred eighty-one days for the orange crew and the green crew estimated 624. Same job? Yes.

Dr. North:

The green crew did not know that it was April 15 when we were doing it, and the school was to open in September of 1969. You can see the green crew now has a couple of long evenings with the superintendent to revise their estimates and fit them into some of these deadlines given to us.

Dr. McIsaac:

As you look at that output, let us take a quick look at the orange team. They came up with a 301 day estimate. Let me put this up so I can help you interpret the information that you have. This is the first sheet, and it is really the important sheet, because it has all the information that you might need.

Remember the preceding event number and the succeeding event number as taken off of that diagram, the flow or PERT network chart. This column is the responsibility listing. This column is the list of activities and this column is for information purposes. It provides an opportunity for you to indicate that the activity is completed, scheduled, or in progress. Each activity

is in one of those three status conditions. You can also enter the date you would like to have it completed here. That is alpha-numeric information and you write in June 30th. This column has nothing on your page, because there are no estimates.

Duration - one thing that I did not mention and go into any detail at all. It is also possible to include cost estimates for each of these activities, so this list would also give you an analysis of the cost.

Then we have the earliest start, earliest finish. Now this is measured in days, from the beginning time of the project. For instance, the orange team says that it is going to take 45 days to select a principal. The duration is 45. The earliest start is 0, because that is the first activity. The earliest finish, then, is obviously 45 days after the beginning and also is the latest start and the latest finish.

One comment that I would like to make (now that you have this in front of you) is that obviously this is not the schedule that will be followed precisely all the way through the project. In other words, you do not put this up on the wall, put a nail in it, frame it, and say, "It is the second week, and we are off schedule." What you do is to review, because obviously these estimates are going to need to be refined and are going to need to be re-estimated as duration of the project proceeds.

As an adjunct to this set of output, there is also a responsibility list where each of these activities is broken out according to responsibility so that individual number one would receive all of the responsibilities assigned to him. He would then make corrections in those estimates and return that sheet for a subsequent run. Then, obviously, what you are interested in as an overall prospective is to look back at the overall duration: is it getting larger or is it getting smaller? In other words, are the original estimates too small and the project is going to take longer, or are the original estimates too large and the project could be done more efficiently.

The process of review, the process of update, is just as important as the process of establishing the original network. You cannot say that this is set, and I think you realize that some of these activities may have unforeseen delays. At the time those occur, you ought to assess the delay, re-enter a new estimated duration, and run the whole thing again.

Incidentally, it may be of some interest to you that the actual computer time was 41 seconds. You see the solution to that little network. Things happen rather quickly in the computer. It was the human system that made you wait 10 or 15 extra minutes.

We now have an opportunity to analyse and contrast the differences between the orange team and the green. If we look at the

the listing itself, we see that the green team has a 624 day estimate. Their selection of the principal was estimated to be 30 days. Let us see which of the activities here that were noted as taking a long time, would add up to such an amount of time.

Prepare courses of study. Now there we have a real interest in developing a new course of study for this school. There are 180 days of time estimated for the adequate preparation of courses of study. We have 190 days estimated to select department heads, and a 120 day estimate for the approval of the curriculum specifications. The green team is going to spend some time on curriculum.

If you look at the last page of output, you will notice that the critical activities are listed. All of those activities on the activity list which appear to be critical are broken out and listed separately. You will see that on the green team the critical activities include the selection of the principal, which obviously would be critical, because nothing is happening at the same time. Other activities include preparation of the public information program, selection of department heads, planning the administrative organization, selecting and assigning teachers, the preparation for courses of study, training of teachers, conducting teacher orientation, and preparing rooms for instruction.

I am not certain how you would interpret that activity "train teachers." I think from the point of view of the school district, it presumably employs teachers who have been proved valid in educational programs. The training of teachers could bring to mind a whole different array of courses or activities which might be involved. This might be the kind of activity which would subject itself to a high degree of variability in estimate.

Question:

How do you program that computer to break out those critical activities?

Dr. McIsaac:

As the computer solves this network, some of the activities have zero total slack. In other words, the computer analyzes the network and says, "this path is the longest or critical path through the network."

Question:

Which is the critical path?

Dr. McIsaac:

That is a good question. It will be different for the two different networks.

Dr. North:

A point would be that the critical path would change through this revision process. It is very important that this point out to you as mamager of this operation where your problem is. Say you have responsibility for one activity such as placing equipment. You may be sitting there thinking you are a good fat cat as you are not on the critical path. However, because of somebody's review cycle and completion, I get a printout the first of next month and say, "Now, I am on the critical path."

Question:

Are the first two activities always going to be on the critical path?

Dr. North:

Always, obviously.

Dr. North:

This curriculum development is the point that is holding up the green team. In our way of operating, I am sorry to admit, we would say, "Ah heck, boys, we will take that curriculum from down the road," or "We will take the curriculum in that school that we are trying to replace and so in the end nobody will know the difference." I do not think that is sound planning. I think this tool will encourage us to take a sounder approach to this planning process.

Dr. McIsaac:

For an alternate critical path, we will go in this direction where the critical path is only slightly different, but I think that if we analyze the difference between these two estimated networks, we would find that this activity, 200 - 450, has a much longer duration in the second network than it does in the first. Sixty days is what we have estimated for this activity, Selection of the Administrative Staff. The major difference in these two networks is that the activities along the critical path are much longer for one than the other.

Question:

How are you determining the sequence of priority; not by duration and time lapse?

Dr. McIsaac:

That is correct, as sequence is the planning dimension you wish to analyze. As a user of this kind of tool, you say, "This activity cannot begin until that activity is completed. We cannot appoint teachers in the science class until the department heads are appointed."

You say, "We will appoint the department heads," and you say, "That is an activity." Remember, an activity is an arrow surrounded by events. Then you say, "How are we going to appoint teachers or select teachers?" Now this is the policy that you are administering. Does this happen after you appoint department heads or does it happen simultaneously? That is the decision which you make, but you are limited in the kinds of decisions. You do not have to say you are going to schedule it. What you say is, "Here is the interrelationship, and that is how you portray it." Then the computer does the analysis as a scheduling process.

The hard work (and I think that you probably perceive that), is the identification of activities. There is no computer help for that.

The responsibility. There is no computer help for that.

The estimate of duration. There is no computer help for that.

Those are the four activities that really have to be done in order to make this useful, but they really should be done anyway.

Dr. North:

These are management requirements for any operation. We would say, would it not seem logical that there is a best sequence of educational activities for your district in the same way that there is sequence in the construction that has been designed for your building? In other words, you cannot put the masonry and walls up until you have the footings in. The construction network varies by design too. You architects could explain this more clearly than I could. But in most construction today it is the pouring of concrete that basically turns out to be the ciritical path, because there is so much concrete that goes into these buildings. When you get down toward the end, it is the finishing sequence and hanging of stuff. The critical path for differently designed buildings would be different just as the critical path for school districts with differing policies would be different.

Dr. McIsaac:

Let us say that you wish to, in a construction sense, build a building that is made of five different parts. One could analyze each one of these separate parts of the total complex building A, B, C, D. One could then say A represents one entire network representing the completion of building A. Next we might have another network which would be building B. It is possible to finish Building A and then start Building B. The solution of this network might take perhaps 171 working days and might then have some sort of estimate as to how this would fit on a calendar. Obviously, the total estimated ommpletion time of that project is 371 days.

On the other hand, you might say let us employ two completely separate crews and build these two buildings simultaneously using those pieces of equipment that we can share, but our objective is to finish this project in 200 days. The PERT network suggests that if we have a beginning here, the end would be 171 plus 200 days. If you build both of these buildings at exactly the same time, then you have both events going to the end together, or 200 days to complete both projects.

Or, you might say, let us meld the activities that go into this construction together with the activities that go into that construction. We will dig the ditches here and then move right over and start digging the ditches there. When we put in the footings, then we pour the basic concrete. We will do a swinging bucket sort of thing--we go to one end and then the other, back and forth. The completion time would be within 200 plus whatever the solution of that kind of a sequence of activities would suggest. You really decide what the order and sequence is and then say, "What does that tell me? That is not good enough. We are not going to finish it in enough time. Then you make some adjustment in the network, a logical adjustment, and that will accelerate the time.

Question:

Do the dummy activities give you some extra time, flexibility in timing; like for strikes?

Dr. McIsaac:

That is not why they are there.

Question:

They do not provide it for the critical path?

Dr. McIsaac:

No, they do not provide any slack at all for the critical path. What they really do is express logically those interdependencies that do, in fact, exist. For instance, you may finish this activity and be completed, but what this network suggests is that the beginning of this activity is contingent upon the completion of this activity and that activity. So this dummy only says you cannot begin this activity until that one is finished.

Dr. North:

You would say one activity was installing equipment, final installation of equipment and another would be the acquisition of staff. What they are saying is that you cannot open school, which is the end activity, until you have both equipment and the acquisition of staff although these activities could go on independently and require different times.

Dr. McIsaac:

The activities which follow cannot go until both preceding activities are satisfied.

Dr. North:

A point here. I think that the review process is not completely clear in our minds. It seems to me that as a management tool, this technique, the printout, and a responsibility designation is a good focal point for staff meetings. We have seen two different types of staff meetings held when this process is gone through.

We have a meeting and the superintendent, the project supervisor, or the architect says, "Well, boys, let us see where we are and how you are doing with equipment." We get to talking, and we seem to just be wandering through a maze of problems. Where this printout is the focal point, and we direct our attention to that, it seems to me that our attention is given to the actual problem. This being the point; that this network and printout would be an ideal communication tool, which seems to be the basic problem of an executive.

In other words, here is a way of getting two specialists or a group of specialists together to talk to a point. We say, "When can we install equipment? Somebody else may be holding up the show!" It seems to me that the communciation potential fo this technique is one that we should thoroughly investigate before we say yes or no to this as a possibility.

Question:

Computer technique can never make decisions? It can only point out areas that require attention?

Dr. McIsaac:

Right. If you could program the decision itself, the computer could, in fact, make the decision. For instance take an analysis in terms of time and cost which has fifteen hundred different networks and representing an interrelationship of time and cost. On the basis of some predetermined ration of time and cost the computer could select a specific schedule.

As the administrator you look at this and say, "the fifteenth. If we abandon the public information program, we do not have some plan to tell the community about this school, and we are falling behind.

By the fortieth day, have we got the school boundaries determined? Is that done yet? No, better do something about it, because we are ten days behind schedule." Or, "It is done, and we are in good shape."

The thirty-fifth day we have Organize the Curriculum Study. Is that started? That has to be completed, because it is the latest finish that I am looking at, the forty-fifth day. These are all of the activities less than fifty which, if they are not completed by today (assuming that today is the fiftieth day of the project), put us in trouble. We should do something about it.

Dr. North:

They would show up very clearly on the revision that we would run, but you could get them by interpretation.

Dr. McIsaac:

This list right here of the earliest finish can determine which are falling near the fiftieth day. These are activities which ought to be finished right now. If we are not finishing them, we are not in serious trouble, but we should be beginning to get them finished.

The other question is, "Which activity have we started. Which one should start by the fiftieth day?" Obviously, there is a whole list of them here that should have already been started. Looking at this dummy activity, Select and Assign Support Staff, we find that it occurs on the sixty-eighth day. That means three weeks from today I have to be ready to have that done. This

network is providing that kind of information.

On the fifty-fifth day, menaing next week, there should be a Materials List ready to approve, and it should be approved by that time.

The earliest start column, the one I have not yet reviewed, is used when you review the latest finish column. If you find something that is coming up, the fifty-fifth day, you say, "Well, it should have begun on the forty-fifth day and did not." In other words, is this the kind of activity that is going to be potential trouble? What this is doing is to highlight those activities which are current and emphasize in the critical activity list those specific activities which are, in fact, critical.

Dr. North:

The interpretation of that sheet would be the agenda for the staff meeting held to check this. The interpretation would have been made in advance, and that would be our starting point.

Question:

Can this be used to make a bar chart like an engineer's flow chart?

Dr. McIsaac:

Yes. As a matter of fact this is, in a way, an offshoot. This project was developed by Booze, Allen, Hamilton, a management consultant firm, on a Navy project. The purpose was to make more specific that information which would be in their bar chart. For instance, this network can be drawn in such a way that this dimension represents the latest finish or represents the earliest start for each one of these activities. It does, in effect, give something of a demonstration of that bar chart.

It is also possible to draw these with arrows and with dotted lines beyond the arrows to represent slack time. This is another technique that is used and then it is precisely synonomous with the bar charts. It has the additional information which is the printed output from the computer. It is very simple in a way.

Question:

In terms of the experience that the writers had and the reception and understanding by architectural firms of this Critical Path Analysis to a new building project, how do they adapt it to

their planning?

Dr. McIsaac:

It is an exceedingly perceptive question. This is one of the questions which always gets raised. Whose baby is this? Whose responsibility? The architects want to know how to pass it on to the contractor. The contractor wants to know how to pass it back to the architect. The school district would like the architect to do it. In fact, the primary responsibility, it seems to me, belongs to the owner.

The owner can use that primary responsibility in a variety of ways. The U. S. Government, for instance, uses that ownership responsibility to say to the architect, "This is your responsibility. You will report to us in terms of Critical Path Analysis." That pretty well establishes the format, and how it is going to be done.

Question:

What is originally in the relationship between the administration or the owner and the architectural firm as they proceed in this critical point?

Dr. McIsaac:

One problem that comes up is the assignment of responsibility, and that is required before any kind of a project begins.

Question:

By the owner?

Dr. McIsaac:

By the owner! The owner should clarify the responsibility. That is the school board, of course. Get that squared away so that everybody knows what is going on.

The second part of your question relates to the project we have been associated with. It has really served to enhance the communication between the architect and the school district. Let me point out that there was an intern involved in this example project. The intern, as a representative of the school district, was very much involved in the critical path analysis. He, in fact, served as that interface of communication between the architect and the school district. I think that, primarily, is the

advantage. I cannot cite this as solving all communciations problems, because I do not know of the kinds of disadvantages or rubs that came up. I think that what it tended to do was to focus areas of difficulty for both parties.

Question:

Could we get a reaction from any architectural representatives here on that?

Response:

The biggest problem that we have run into is the enforcement of this time allotment. Although the contractor may say we will have men there within forty-five days, at the last minute he says, "I cannot get it. I did not order in time." How do you enforce this? "There is another job to finish, and I will not have my men here for ten days." You review and you change, but this does not happen once. It happens a hundred times on a project.

Dr. McIsaac:

Let me ask this question. Who is responsible for the estimate of how long that will take?

Response:

We go to the contractor first and let him estimate. Then his subcontractors estimate the time. Then we review this with the contractor.

How often? Let us say, when we came to a job we would review the estimates with them, and then as we move through we have weekly or biweekly job meetings, and things usually fall behind. It is so many times that they have to be changed, because someone just is not ready. They failed, forgot, or cannot get it. Suppliers are on strike. There are so many excuses. There is no way to enforce it if the contractor is just lazy and does not want to do it.

Dr. McIsaac:

What you are saying, then, is that it is the contractor's responsibliity. If he does not get the building finished on time, then you have got some recourse. It seems to me that the consequence of the entire series of delays, delays the building itself. Does it or does it not?

Response:

But you could not have a good experience with these penalty clauses in there.

Dr. McIsaac:

Does that suggest that the contractor himself might benefit from the use of a PERT program?

Response:

A contractor who really attempts to follow it can benefit.

Response:

I think that one thing we have to understand is that this technique calls for a certain amount of money. We have to evaluate. We have to be able to say, does it have values? Does it make a difference if the building is ready for use in February of '70? We cannot answer that as architects. I think the client has to answer to the value of this kind of thing. I think also we see a sophisticated management technique here in place of an otherwise kind of sloppy management process.

Question:

Would you find that this changes your supervisory role to any extent because of this?

Response:

Well, it gets the job done. It can tell us more accurately where we are, and it can tell us further ahead when we are going to have problems. You could use it for predicting delays. If you have a school that has to be opened next fall and you have teachers coming to teach in that school, we then have a predicted crisis if that school is not ready. In November when the hollow metal is not on the job, we know where we are hurting. Sometimes we did not know where we were hurting until it was too late to do anything about it. I think I can save money for a contractor.

Response:

I think it is safe to say that we have built many buildings using critical path technique. When you open bids, it is customary

not only to have the price and the number of days of construction, but the contractor is initially binding himself to that 200 or 171 days. If you build a critical path based on this, every time you have a monthly job meeting you can check the computer to see who is building it up. The sharp architectural superintendent knows that the biggest pressure you have is the natural economic pressure of the contractor. If a bonder is goofing off and is four or five days behind, you are going to know this. If the next guy, the painter or the other people who have money invested in the project, will be starting late, the most effective pressure is that natural pressure of the peers, the other contractors on the job. They know who is costing them money, and it does not take much persuasion on your part as an architect or owner to point this up in the meeting. This is the guide, the computer shows this.

Question:

Is this what we have been doing for years, even without this system?

Response:

Yes, we have.

Question:

What is the difference, how does this affect your performance?

Response:

The difference is that I can tell you every single day, every single guy that is holding up in all details. I have not been able to do that scientifically up to this point.

Dr. McIsaac:

We have here a more sophisticated management technique. Would you have the bid include the network when a contractor bids on a job?

Response:

Yes, the owner automatically always ..... anyway whether you say it directly or indirectly.

Question:

Does this change the form of your contract?

Response:

No, not a bit. It should not.

Question:

What control is exercised on these various subcontractors?

Response:

The general contractor has total responsiblilty for the schedule. He has only one day to meet and that is the final one. That is the final delivery of the building to the school board.

Question:

He has a penalty clause in the contract?

Response:

The Critical Path System can show you his relationship with the final date. It does not do much else. You know who is responsible, however. You cannot pass the buck. At least that is what the difference is.

Question:

You would have two sets of these, one for the educational setup and the next one for construction. We get them all mixed together here. Or do you make all this one?

Dr. McIsaac:

I think conceptionally at least in the initial part of an analysis, it is obvious what we are suggesting is that there is a use for this approach in the development of the educational program which is separate from the construction programming. If they are developing an educational program for a school and you are developing the school itself, there is a point in time that these two come together. They are made, in fact, together as the restraints or constraints go from one network to the other.

Question:

How big a bill are we talking about to computerize this sort of thing when the two interrelate?

Dr. McIsaac:

Generally speaking the people who perform a Critical Path Analysis for large construction charge somewhere between .5 and .8 of one percent of the cost of construction. This is just a general rule of thumb. The larger the construction project, the lower the percentage.

Question:

That is just in the construction one, not the education one?

Dr. McIsaac:

Right, this is the general rule of thumb for estimating the cost of this kind of thing. First of all, the cost is divided up into a couple of different parts. The first part is the establishment of the original network and the original duration. That initial estimating process might be 50 percent of the total cost of establishing the network. The review process, once the network is established, is much easier to maintain and generally goes on for the duration of the project, and constitutes the other 50 percent of the total cost.

Question:

There is a businessman and an educator working together and the question arises as to what part and how much? How is that arrived at?

Dr. McIsaac:

I think in the final analysis, as said a minute ago, the owner is going to absorb the bill, both bills essentially. The requirement as to how it is done, is not as important as that it is clearly defined. The owner is paying the builder for this kind of service. Did I answer your question?

Question:

Not really, because when the owner is not curious it is apt to cost you more. If he makes a definite arrangement beforehand,

it costs him less. How do they do that when they combine the business end and the education aspect in the same process?

Dr. McIsaac:

In the situation where we have done this, it has been the owner who has made arrangements for both. I do not think there are very many people who have made the educational application.

Dr. North:

The points that Howard Wakefield made would apply, whether you involved any of this, because we will probably continue to sweep a lot of our problems under the rug and not prepare our curriculum in 180 days as the green team decided. I am not so sure that there are not many economies or pressures inherent in CPM and PERT which might cause us to be a little more critical of our management processes to date. I am not saying that we as a group are more direct in these management processes than business. I had a chance to sit at that table for two years, and they made the same mistakes, but they have a public relations man to cover it up. We cannot get that right now.

Question directed to John Knapp:

What experience have you had under separate prime contracts?

Response:

We set up a critical path for each one. I figure it depends on whoever your programmer is. You have got the architect, contractor or contractors, and the programmer together to make this network. They are not easy to get together.

Question:

I just wondered who you are talking about in "passing the buck".

Response:

Once it is under critical path, you cannot pass the buck any more. If you get to the fifty-first day and you are not on the job, it is your baby and everybody knows it.

Dr. North:

Contractors are, quite frankly, interested in this to the extent that it can help them. Some contractors see this as a very important tool for fitting their subcontractors together with the other prime contractors as is done in many states. Those contractors look upon PERT in this manner, and they use it as part of a reporting system. There have been several case study failures in the area of this technique. You do not need a case study to see when the system is a failure. When the first run is tacked up on the wall and looked at as a schedule instead of looked at as the communication tool, as an encouragement tool, a review tool, then the system has failed. It would be hard to discern why it failed.