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ABSTRACT

The Information System for Vocational Decisions (ISVD) places Boocock's (1967) Life Career Game in the core of its operating system. This paper considers the types of interaction that will be required of the system, and discusses the role that a career decision game might play in its total context. The paper takes an into-the-future look at the day when an artificial intelligence system guiding simulated counselor, teacher, and career generator systems becomes a feasible programing task. Toward this ultimate goal, the author proposes to start with the career decision game, and to develop the full system as a series of increasingly complex modifications of its basic format. The game in its present form is described and its use as a miniature model for the entire system of interacting simulations (teacher-student, counselor-client) is discussed. (TL)

INFORMATION SYSTEM FOR VOCATIONAL DECISIONS

Project Report No. 25

IMPLEMENTATION OF A CAREER DECISION GAME ON A TIME SHARED COMPUTER: AN EXPLORATION OF ITS VALUE IN A SIMULATED GUIDANCE ENVIRONMENT

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Preface

The Information System for Vocational Decisions places the Life Career Game of Boocock (1967) in the core of its operating system. The game has this location because it is a means which the inquirer has to engage in life planning in ways in which he can subject trial decisions to tests of their consequences in our existing societal arrangements both in terms of facts imputed to another and in terms of facts holding for himself.

There are two forms of writing within the ISVD project about this gamelike possibility. One form of writing is about the game itself and about its implementation in the ISVD as the system takes its more final condition. The other form of writing is about what the game idea can contribute to the understanding of decision processes of persons in education and of designers of the ISVD itself. This paper by Roman is of the latter kind.

This paper was originally issued as a working paper in February 1967. We now reissue it as a Project Report because its ideas have not yet been superceded and because those ideas deserve attention from the wider audience within reach of our Project Report distribution.

David V. Tiedeman

31 October 1969

IMPLEMENTATION OF A CAREER DECISION GAME ON A TIME SHARED COMPUTER: AN EXPLORATION OF ITS VALUE IN A SIMULATED GUIDANCE ENVIRONMENT

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The general goals of the ISVD project are stated in its proposal to the granting agency and in other literature (Annual Reports, ISVD, 1966-1969). The purpose of this paper is to consider the types of interaction that will be required of the system, and to discuss the role that a career decision game might play in its total context.

The users of the system will include many who will find that the stylized rigidity of ordinary computer programming interferes with their purposes. These people must express their thoughts in an English-like language, and should not be burdened with unnecessary details of programming. A polite diagnostic system should instruct them when they err. Others, in the interest of efficiency, will want more direct communication with the programmed systems, and they too should be satisfied.

ISVD users can be divided roughly into the following categories: programmers, educational researchers, trained counselors, student counselors, inquirers in the schools and opportunity centers, and clerical workers. These categories are neither mutually exclusive nor exhaustive; they merely represent anticipated users of the system.

What facilities will be demanded by these users? This cannot be answered without a full understanding of the highly abstracted functional units of the system and their interactions (See Figure 1). The final

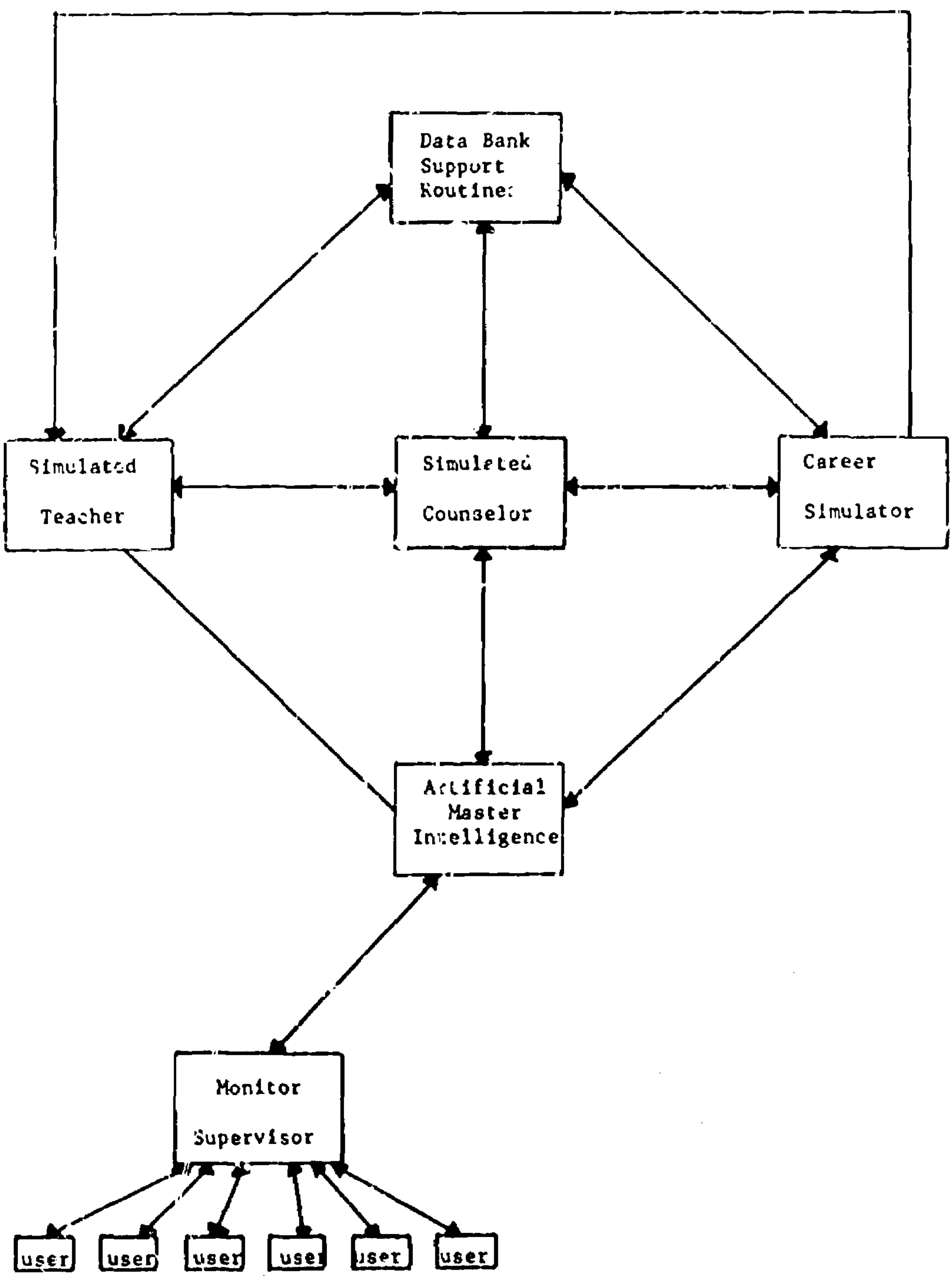
Data Bank
Support
Routines
Simulated
Teacher
Simulated
Counselor
Career
Simulator
Artificial
Master
Intelligence
Monitor
Supervisor
user
user
user
user
user
user

Figure 1

prototype of the ISVD project will be characterized by a programmed supervisor interfacing between the users and the internal routines, a data bank and supporting routines, and an artificial intelligence system controlling the operations of the simulated teacher, simulated counselor and simulated career generator. All of the routines will draw on the data bank extensively, and will be controlled by the artificial intelligence. The supervisor will determine which user is to be serviced next, and assign space within the computer.

One of the goals of the ISVD project is a clearer understanding of the guidance process. One of the most successful methods for forcing clarity in thought is simulation. In simulation, the important processes to be modeled are abstracted and written in the form of a computer program. This program works or fails, and thereby indicates the strengths and weaknesses of the model.

We in the ISVD project are interested not only in imitating what the counselor does do, but in doing what the counselor would like to do. The computer can handle larger amounts of information than a human being. Therefore, if we specify the information transformations carefully, the computer can surpass human performance in this regard. This is one aspect of what is called artificial intelligence.

Artificial intelligence in this paper will be a general method for measuring performance and improving on it. The specific task is irrelevant to artifical intelligence, since it applies high order heuristic rules -- such as goal seeking and subgoal formation and working backwards from goal to present state -- to a variety of tasks. Thus, one artificial intelligence routine can be applied to a simulated teacher, a simulated guidance counselor, and a simulated career generator.

In short, the artificial intelligence system is a routine that includes the tools for learning to improve performance. These tools will be applied to each of the simulation routines developed for the project. Simulation and artificial intelligence thus go hand in hand for the purposes of the ISVD project. In the simulation stage, the present methods of decision-making are specified; in the artificial intelligence stage, the methods for improving decision-making are explored.

The artificial intelligence system functions by guiding the subordinate simulation routines. For example, it could tell the simulated teacher that more importance should be given to how long the student takes to answer and less to his IQ score.

Consider the simulated teacher in more detail. The simulated teacher will have a variety of methods for presenting concepts. These will include various media of presentation, different vocabulary levels, and different logical sequences. It will also have available the student profile containing data on socio-economic status, test results, school records, and personality measures. Finally, it will have records of previous lessons that will include errors made, latency of response, and character of the material.

Many of these factors will be taken in account as the teacher decides what material to present next. Some factors are clearly more important than others in the decision. This will be taken in account by weighting each factor differently. The teacher will use the assigned weighting of factors until some estimate of its efficiency is made by the artificial intelligence.

The artificial intelligence system will have access to a vast variety of individual records, and can look at the whole picture in a way the teacher is too restricted by its position to manage. With this broader perspective, the artificial intelligence system can determine a better way of weighting factors. It will then give the new set of weights to the teacher who will proceed with them as it did before.

The critical and difficult question this procedure leaves is to define precisely what is meant by better teaching. The system will approach whatever goal is set. Setting the right goal is the project's responsibility.

The other two simulated systems are more specialized than the teacher. The simulated counselor will look at the student profile and create suggestions and recommendations for the student. It might suggest a specific test to gain further information, or list relevant occupations for the student, or compute frequency tables for success in particular jobs.

The final simulated system is the career generator. This would be a probabilistic model that would predict the course that a person's life would take, given a past profile. This past profile could be the up-to-the-moment history, or the history supplemented with a decision to pursue some action in the future. It could be asked questions like: What will happen to John if he decides to major in Far Eastern studies? What will happen to Mr. Smith if he goes to night school and finishes his high school work? The answers would be probability statements, or best guesses at the actual results. This routine could have a recursive feature, which would allow it to pursue a person's career through several discontinuities before returning an answer.

The key to the effectiveness of all of these simulated systems is the usefulness of the data bank. The stored data and the easy access to material in the bank would allow all of the simulated systems to be pre-tested on the records of the individuals. In this way, the initial settings of the parameters could be determined without risk to those using the system. No advice need be followed; no career plan fulfilled. The machine can make many errors as it develops an estimate of the best plan for action while interacting only with data. Once the estimates became stable and reliable, researchers could determine their relevance and realism by further testing from the data bank. If the machine's estimates seemed dangerously far off, the researchers could adjust parameters to obtain results they thought were more realistic. After further calculations utilizing the adjusted parameters, another feedback session would be in order. In this way, the program could avoid local maxima in the multi-dimensional spaces in which they will work. Periodic checks by skilled members of the simulated professions would guide the computer on its search.

The three simulated programs would interact with one another, each supplying its best estimate of the effects of the other's actions. The simulated counselor, for instance, would look at the profile data of an individual facing a discontinuity. After considering the relevant information, it would make a decision, and submit it to the career generator, which would then simulate several years in the individual's life. The resulting projected profile could then be scored by the values included in the profile. Next, any discrepancy between the ideal and the actual projection could be minimized by testing alternate decisions of the career generator. When the minimum discrepancy is encountered, the artificial intelligence system could suggest new weightings for the guidance counselor to use.

Similarly, the program designed for teaching might be applied to teaching decision-making skills. It could call on the simulated guidance counselor to aid in its estimation of the student's skill.

All of the above is idealized, and far from a feasible programming task in the immediate future. There are available some approximations to the kind of programming required, but the scope of this problem is far beyond the capabilities of any existing program. We must consider ways in which we can move toward this ultimate goal. The system must be useful before it reaches the level of sophistication for which we are striving. There are approximations, which can be implemented simply and quickly, that would serve as a basis for expanding the system to full power.

One possible plan is to start with a career decision game, and to develop the full system as a series of increasingly complex modifications of its basic format. Such a game would reduce the level of abstraction required for the initial development of the system without changing the fundamental questions ISVD must answer. I am not suggesting that the game is in any way necessary to the project. It would be dispensible at any stage of the project, and serves here only as a focal point for the developing system.

The starting point for my thinking was the preliminary version of a career decision game devised by Eugene Wilson. Since literature about this game is not yet available, I include a summary here.[1]

The game consists of a series of discontinuities to be solved by the player. A *discontinuity* is a choice point in a person's life. For example, choosing a pattern of courses in high school, deciding on a type of college, or picking a major are discontinuities. A discontinuity is solved when a firm decision on a course of action has been made.

The player is presented with a discontinuity and a personal profile sketch, which includes the name, age, and sex of the person facing the discontinuity. The player assumes the role of the person in the profile, and tries to gather further information from the complete profile to help him clarify factors bearing on the decision. The additional information is presented from the profile in the order set by Mr. Wilson; the player cannot influence the order in which he receives the information.

After each piece of information is requested and digested, the player examines the list of alternative solutions to the discontinuity, and tries to narrow the range of appropriate choices for his profile. The game continues until no additional information is available in the complete profile, or until a player reaches a final decision. The player tries to make the decision most appropriate for the person in the profile. Even after all the information in the profile is available, the grounds for decision may not be clear, so the player may have to make his final commitment on value judgments.

The preliminary version of the game has a paper and pencil format. One person presents the discontinuities and information to a second person

1. This information came from my conversations with Mr. Wilson on October 10, 1966 and earlier dates. The game is still being revised, so this report is of my understanding at that time. The revisions and modifications suggested in this paper are solely my responsibility.

who plays the game. The information about these factors is presented in a fixed arbitrary order. The player does not ask for specific information, but must accept the next piece that comes up regardless of its usefulness.

Players who don't know what a particular test score means have no way to help themselves. There is no provision within the game to allow the player to use books or tables. The game contains no specific teaching of decision-making skills. The game will be part of a total program for increasing decision-making skills, in which the student will have instruction before and after the game is played.

There is little need for a computer to handle the present game structure. A regular teaching machine would be quite adequate. However, the many contemplated improvements will introduce complications that will require a computer to handle the data and decision-making functions.

Before the game can be computerized, its structure must be well understood. Figure 2 provides a summary of the game in flow chart form. There are several important lists in the game: *discontinuities* (a list of descriptions of possible discontinuities), *possibilities* (set of possible solutions corresponding to each discontinuity), *profiles* (a list of information about people -- several for each discontinuity), and *judgments* (a list of the relationships between the information in the profiles and the possible solutions to the discontinuity). As examples of the list of judgments, a male could not go to a girls' college, a student with an IQ below 120 could not be in honors courses, a man with a mechanical aptitude below the tenth percentile should not be an auto mechanic.

The game in its present form is completely determined once the discontinuity and profile are chosen. The information presented does

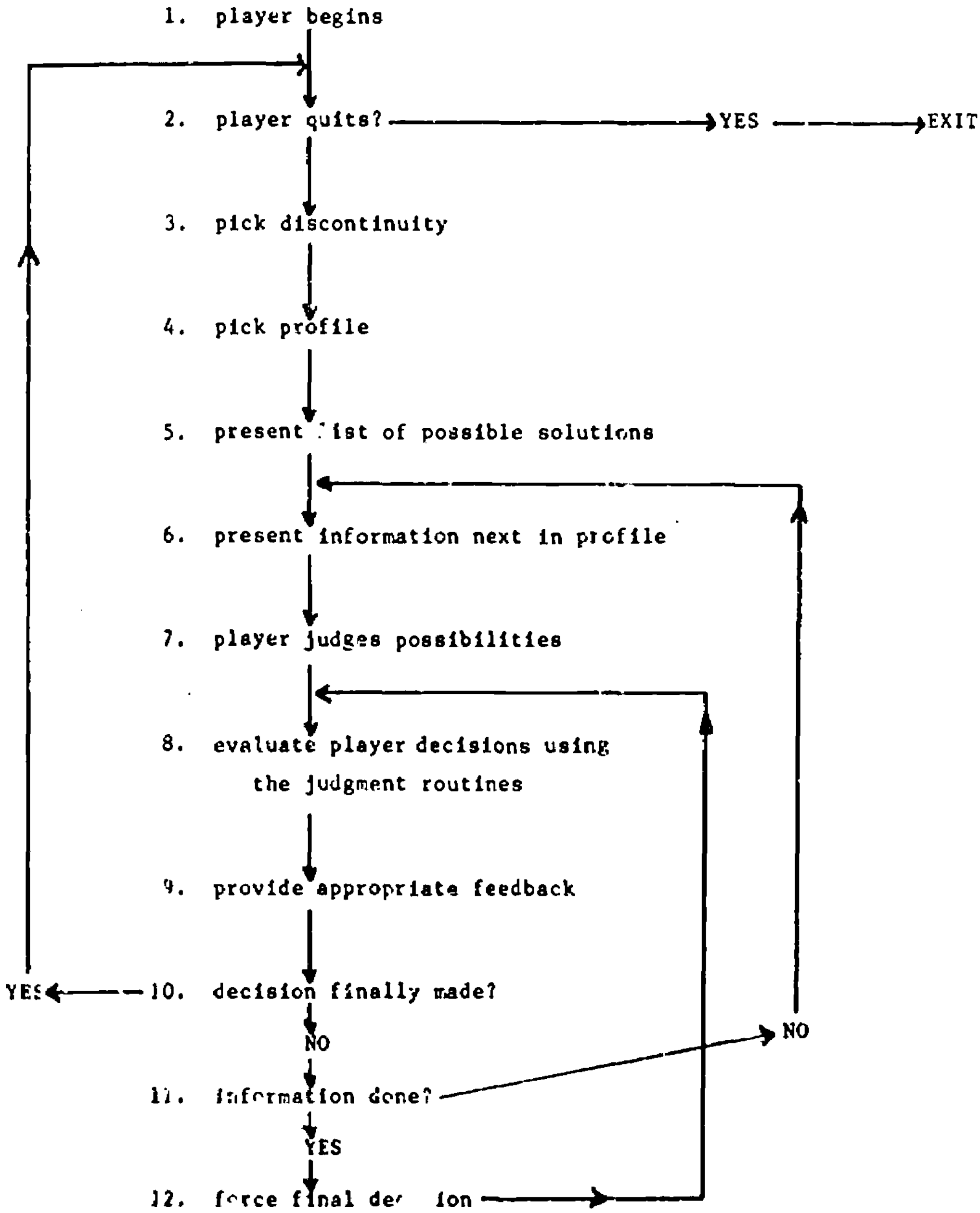

Figure 2

A FLOWCHART OF THE GAME

not depend on the ability of the player, and the feedback is a fixed function of the player's choices. For each discontinuity and profile, the script specifies exactly what information is needed to eliminate an alternative. The script writer must examine every possible response and provide appropriate feedback. He must arbitrarily decide which is the correct choice rather than rely on statistical analysis of similar cases. This is a lengthy and thankless task, one which should not be undertaken for more than a few discontinuity-profile pairs. The information gained by such brute force programming will help us understand the process of analysis, so that we can simulate it later. Results of running the finished scripts will provide some feedback on the properties of the game.

We need to devise a list processing language flexible enough to handle the presentation of material, the complex conditionals needed, and the record keeping required. MINORCA I will easily handle this version of the game. Later modifications of the language will allow it to handle all of the extensions of the game discussed below.

In this discussion below, the game is the starting point for development of the entire system of interacting simulations with which this paper opened. The game will become a miniature model of the entire system.

The game, as described above, will be the early prototype of the simulated teacher. Eventually, the same system will provide all interaction with the users. Extentions of the game will more closely approximate the ISVD vision. Part of the working philosophy of the ISVD project is to provide the student with the opportunity to learn about decision-making, to increase his ability to turn data into information, to help him see how information can be used to solve complex contingencies, and to provide feedback about his performance. In order to facilitiate this improvement in skills, the game could be enlarged to allow the student to enter an "inquiry mode". In that mode, he would seek specific information about the profile on which he was working, rather than passively accept the script writer's order of presentation. This would force him to engage more actively in the process of information gathering and would therefore cause more profound changes in his behavior. If the player found that he could no longer intelligently seek further information or use the data he had gained from earlier inquiries, he could return to the "presentation mode" and allow the script writer to prompt him.

Another desirable modification of the game would allow the student to interrogate the information and teaching files. These files would provide paragraphs about the alternatives from which the student might choose, and information about the test scores included in the profiles. With this provision, the student might ask, for instance, "What is an IQ score?" or "What does an undertaker do?"

Making this feature available has implications beyond the game. The same programming would allow counselors to ask for job descriptions or summaries of college admissions requirements. Researchers could use this feature to ask for statistical correlations and frequency tables constructed by examining the data bank. Information about people with similar profiles would be available from the data bank. This information would be useful to the script writer while he wrote, and would give him firmer grounds for his decisions in particular situations. The player should have limited access to the bank. He should be able to ascertain what happened to others with similar profiles when they accepted each of the various alternatives available to him.

At this point, the process we are describing ceases to be a game. The inquiry mode and the statistical routines are appropriate tools for the student personally facing a discontinuity. Similarly, the counselor can use the routines to find information relevant in guiding a student.

Another function of the game is to provide feedback to the student, and evaluate his performance. This evaluation should become part of the player's record in the data bank. His performance on future trials could be compared with those of the past to estimate his growth. In this way, the game becomes part of the monitoring function and provides useful information about the student.

To "estimate growth," the goals of the game will have to be more clearly stated. Superficially, the game should increase the student's readiness for career decision planning and progress should be measured on the O'Hara scale devised for that purpose. To be a useful measure, the test would have to be given several times. The details of administration and the practice effect on the scale would have to be determined so that scores could be meaningfully compared. The game itself might serve as a test, if performance could be reliably correlated with some external measure. It certainly offers an attractive alternative to the dull paper and pencil tests used today.

As we gain greater understanding of the game by watching students play, a classification of easy and difficult discontinuities will appear. At that time, random assignment of discontinuities for solution will become wasteful. With a more rational basis for assigning problems corresponding to the student's abilities, the game becomes a controlled learning experience for the player. Rounds of the game could be interspersed with lessons or sessions in the inquiry mode. We could increase the student's level of competence by making each lesson depend on those preceding it. After the appropriate lesson, the student could demonstrate his mastery of the new skills introduced in the lesson by successfully completing a round of the game.

When we view the game as an extension of the simulated teacher, it becomes clear that many factors influence the optimal order for lessons. We must ask what we mean by the concepts we use freely in conversation. How do you tell that a person has mastered the implications of the IQ scores? How do you know he has transferred his knowledge from the game to practical situations? How do you know he is improving? How do you measure teaching effectiveness?

These are the questions that arise about the game. In that context, they have concrete form. You can measure score on the game, length of time to make a response, and readiness for planning. You can look at the order in which the student seeks information, and check to be sure he has eliminated all improbable alternatives.

Dealing with the questions in this concrete form will help us discover where to look for the answers to the same questions about the entire system. The closed universe of the game gives us a finite level of discourse that makes concrete the abstractions with which ISVD must deal.

After watching many students play the game, we will be able to discover heuristic arguments they use. Our own play with the game, both as script writers and as imitation players will give us insight about reasonable assumptions to make. These assumptions and heuristics could be built into a simulated game player. The machine could then play the game by our rules and show us how acute and complete our observations were. This would provide further stimulation for observation. This simulated game player is the beginning of the simulated counselor. All we would need to do is to give it real discontinuities and real profiles, and it would arrive at a reasonable course of action for that individual.

In this simulated player, we have relief from the tedious labor of creating scripts for profile discontinuity pairs. The machine can reach optimal solutions as easily as script writers. It needs to have appropriate general material for feedback, and then it can supply particulars for any discontinuity profile pair. We also have eliminated the problem of creating ideal profiles. The simulated counselor can examine large numbers of real profiles from the data bank and select those that make an interesting game.

Similarly, the career generator could begin as a game player. Given an existing profile and discontinuity, it would generate a solution. It would then use the frequency tables to find the probable outcome of the decision. The outcome would be appended to the existing profile, a new discontinuity chosen, and another cycle played. In this way an entire career could be generated as a series of plays in the game.

These programs rely on each other. The simulated teacher draws on the simulated career generator for materials. The career generator uses the simulated player to solve single discontinuities, and integrates a series of discontinuities into a career. The student playing the game supplies an answer which can be evaluated with the career generator. The simulated counselor will provide optimal solutions and feedback reasons for rejecting certain possibilities.

In order for the system to improve its performance, a master artificial intelligence must guide the performance. It will integrate all results and change the way in which internal decisions are made in order to bring the system closer to its goals.

Thus, the entire project can be viewed as a series of modifications of the basic game format. In each stage, the program can supply additional information about the decision-making environment and the users of the system.

The game becomes a model of the whole system. Concentrating our attention on the game is a way of thinking about the entire project. The questions the game brings to mind are but smaller versions of the questions raised by the system as a whole. Similarly, the entire project can be viewed as an extension of the game. Problems solved for the game will give the clues to the answers for the entire system.

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