ASSESSMENT OF THE PILOT APPLICATION OF THE PROCESS IMPROVEMENT TECHNIQUE IN SMALL SCALE FOOD INDUSTRIES IN LATIN AMERICA

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INTRODUCTION

The International Development Research Centre (IDRC) called for three workshops to exchange experiences and develop methodologies related to process improvement in small scale food industries and based on research and industrial engineering techniques that have been successfully applied in larger scale food industries (1).

The IDRC subsequently decided to test, at pilot level, the application of these methodologies in three different food industries in Latin America: the small scale coffee processing industry in Guatemala, small bakeries in Chile and rural cheese factories in Ecuador.

The purpose of this study is to assess the impact of the three pilot projects on the industrial section in question as well as on the research groups and institutions responsible for the projects. Another objective is to provide the IDRC with some guidelines for the incorporation of the process improvement technique into other projects and to make some suggestions as to the follow up necessary in research, application, dissemination and training in this area.

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(1) See documents IDRC-MR 56e and IDRC-TS 48e in which the main results of these events are reported.

METHODOLOGY

The methodology adopted for this study consisted of the following steps:

1. Review of the existing literature on the process improvement technique and technology assessment. The documents reviewed are listed in Annex 1.

2. Development of a methodological instrument on which to base conversations with those involved in the projects (Annex 2).

3. Visits to the countries in which the projects were carried out. The sequence of visits was as follows:

   - 14-18 March, visit to the coffee process improvement project in Guatemala.

   - Before continuing visits to projects, an interview was held with Dr. William Edwardson in Bogotá on 27 April in order to provide intermediate assessment of the study and the direction it was going in.

     In this session it was agreed to direct the project more towards assessment of the methodology used in process improvement.

   - 1-5 May, visits and interviews related to the bakeries' project in Chile.

   - 8-10 May, field work related to the cheese factories' project in Ecuador.

   - Subsequently on May 11, a preliminary verbal report of the study was presented to Dr. Edwardson in a further interview in which points of view as to project impact were discussed. Feedback was provided by Dr. Edwardson and the structure of this report was worked out.

- 12 May, a final interview was held with the director of ICAITI in Guatemala in order to consult information not included in the first visit.

It is important to mention that in Guatemala and Chile two additional projects involving the creation of new food industries were analysed: banana processing (Guatemala - Honduras - ICAITI) and fish processing (Chile - CEDIPAC). The feasibility of incorporating the process improvement technique criteria was analysed for these projects.

On all the visits, open interviews were held with the various groups involved in the projects: researchers, direct beneficiaries (entrepreneurs), union associations and institutional authorities. In this way, total coverage as to perception of the project's impact was obtained.

4. In Mexico, the author of this study then made an evaluation of the different types of impact (economic; technical; social; environmental; impact on entrepreneurial spirit and organization; on the ability to assimilate technology; on the ability of human resources; political; and on the research group) from the perspective of the different interest groups involved in the project.

5. As a result of this evaluation, preliminary recommendations were drawn up and discussed with Dr. Edwardson. This report is a result of these recommendations.

PROJECT ANALYSIS

a) COFFEE PROCESSING (GUATEMALA-ICAITI)

According to the analytical framework of this project, three coffee processing plants were visited: the Aquil cooperative,

the Tanchí cooperative, and a larger scale plant administered by the Federación de Cooperativas Cafetaleras de Guatemala (FEDECOCAGUA). The first two are processing plants in which the process improvement technique has been put into practice and the last was visited in order to have a means of comparison. The visits were directed by the engineer Diego Alvares from ICAITI.

In Aquil, Mr. Augusto Lem Morán, head of the cooperative, was interviewed. Mr. Lem stated that huts for drying coffeee had been built that facilitated the work of moving the beans. He also specified that the introduction of a pulp extracting equipment had led to considerable increases in productivity.

Mr. Lem was consulted on the impact of the courses given as part of the project. The people who had participated were very enthusiastic about them, but their practical results were not very evident.

It was also observed that an important recommendation included in the project (avoid fermenting the coffeee with running water) had not been introduced even though it is something simple.

In the Tanchí cooperative, a technically simple solution (the construction of a water tank) represented, according to Mr. Francisco Vin, the head of the cooperative, a tenfold increase in productivity. In this cooperative, several problems still to be solved could be seen, such as the low degree of efficiency in drying the coffee.

In this cooperative, the members felt very grateful to the IDRC for the project, but stated that they had not yet seen any real benefits as they were heavily in debt. As to the training they had received during the courses, they said they "had not understood everything, but something", and that on the whole they felt pleased.

In both the Aquil and Tanchí cooperatives, the heads stated that their greatest problem was the low price at which they sold their product and that FEDECOCAGUA did little for the cooperatives. This perception was confirmed in talks with the foreman of the processing plant administered by FEDECOCAGUA which was the last to be visited. This processing plant carried out "opportunistic"

work, buying coffee from the cooperatives at the lowest possible price, storing it and when the opportunity presented itself, selling it at much higher prices. It was thus observed that the problem is not necessarily technical but is also of a commercial and political nature.

An interview was then held in Guatemala City with Mr. Alfredo Hernández, manager at FEDECOCAGUA.

Mr. Hernández spoke of the problems found in fermentation, the attacks by fungi and humidity, before the coffee is processed. For this reason, he said, FEDECOCAGUA did not want to continue with the process improvement programme, unless a solution was found to this type of problem.

Mr. Hernández considered, however, that the project does have a good future, but that before participating more actively, it will be necessary to think things over. He also pointed out the serious problem of the lack of trained personnel to fulfill the goals drawn up by FEDECOCAGUA.

He also emphasised that something he liked very much about the methodology applied by ICAITI was that they listened to the producers' opinions and that gave a firm basis for the programme's success.

Finally, conversations were held in ICAITI with Ricardo García, Diego Alvarez, Francisco Calzada and Ludwig Ingram, all engineers.

The first three spoke about the application of the process improvement methodology in the case of coffee. Here, there was definitely more attachment to the industrial engineering part of the methodology than to the administrative part. The operational diagrams had been adequately drawn up, "bottle necks" identified and, very importantly, they had designed solutions <u>with community participation</u>, in spite of the difficulty to gather together people who were scattered all over the countryside. Thus, this project was an advance in the experience of working with rural groups.

However, the author of this study considers that there was a marked absence of creativity in the search for solutions to problems.

Everything seems to indicate that alternatives were not sufficiently explored and this led to the adoption of solutions that were too complicated and costly. For example, the construction of huts to protect the coffee beans against rain was a complicated solution given Aquil's location. The problem could have been solved with a plastic sheet that would have been much cheaper, and easy to transport and install.

As for the opinion of ICAITI's management, Mr. Ingram considered the project a success and said it would be good to contemplate the possibility of continuing to train people who could reproduce the technique. However, Mr. Ingram gave the impression that he had not become very much involved in the project and that the most important thing for him was that he was financed for a fairly long period of time.

With regards to assessing the impact of this project, a previously designed instrument was applied to the researcher (Ricardo García), the official responsible for the project in the IDRC (William Edwardson) and the project assessor (José Luis Solleiro). José Luis Solleiro based his answers on field observations and the interviews with the different people involved.

In this way, it could be clearly seen that the group that benefitted most from the project was the research group that considered it had obtained a high level of learning in the analysis of technological needs in rural agroindustries. It is also worth noting that the technical and economic impact on the cooperatives analysed was significant. This is probably due to the fact that in an industry with such low levels of technification and organization as in these rural cooperatives, the application of any measure has important effects (in accordance with the Law of Diminishing Returns). It is then important to insist on the point mentioned above that the least expensive and least complicated alternatives possible should be sought, since in any case the results to be expected are considerable if we keep to this maxim from industrial engineering. The social and organizational impact is moderate, as is the impact on the abilities of the personnel. This situation is worrying because it may mean that the presence of IDRC technicians has not been significantly meaningful for the

cooperatives involved to continue applying the process improvement technique independently. This is a point that must be given more attention.

Finally, the insignificant effect of the project on environmental aspects and future political decisions is apparent. In the first case, it would be particularly important, since it is a question of improving processes, to consider not only the products but also the waste as lack of ecological culture is a problem that is beginning to be very dangerous in Latin American countries.

As for the political impact, it is alarming to observe the little concern about "selling" the idea of a methodology, that could be of great benefit, to groups that can channel resources. Definitely, neither the researchers nor their authorities became involved in the task of promoting the project. This means that IDRC support will have contributed to there being two or three very grateful cooperatives but that the effort is limited to this alone and that the problems of this sector in Guatemala will remain unchanged. This is certainly an aspect to be considered in future projects.

b) PROCESS IMPROVEMENT IN BAKERIES (CHILE - INTEC)

To analyse this project, reports corresponding to its two phases of development were reviewed. Subsequently, under the direction of Claudio Simian, the bakeries "La Cabaña" (where Mr. Isauro Díaz was interviewed) and "San Alberto" (Mr. Pelayo Silva) were visited. Interviews were also held with the projects' technicians, Pedro Miranda and Germán Johansen, and with the authorities of the Federación Chilena de Panaderías (FECHIPAN). Finally, there were talks with Bartolomé Dezerega, the director of INTEC.

The application of the process improvement methodology in this project had a marked tendency towards input analysis and the determination of factors affecting the quality of the end products. Aspects such as equipment, administration, sales, energy consumption and equipment maintenance were considered to a much smaller extent. This emphasises the fact that the method was only partly applied.

The entrepreneurs consulted stated having benefitted from the project as they are now aware of the problem of quality control and some aspects of the process such as fermentation times and the use of bread improvers. However, Mr. Pelayo Silva commented that the baker is usually very conservative and does not become completely involved in this type of project, although "most of them get something out of it".

In the interview with the entrepreneurs, it was also detected that they were aware that they have multiple administrative problems and that the provision of wood for their ovens is also something that merits their attention, as "it's running out". It was apparent that these two aspects were not sufficiently tackled in the project.

During the interview with the technicians, several problems in applying the methodology were detected:

First, the low level of participation of the entrepreneurs and the lack of a technical support team in the bakeries meant that the project's technical group lacked a valid speaker in the industrial sector.

Thus, perhaps due to excessive depth in the analysis phase, the application of furtherance techniques to creativity was never achieved, nor were criteria designed to qualify improvement opportunities. In short, it can be assumed that the phase of the contribution of solutions to problems was barely initiated.

Somewhat in contrast with the position of the individual bakers, the members of FECHIPAN's governing body showed great enthusiasm over the project as they considered that, with good diffusion, a change in attitudes could be brought about. They were also consulted as to the idea that FECHIPAN should create a small technical group to continue the work resulting from the project's recommendations. This idea went down well but they were not one hundred per cent convinced. Perhaps this is evidence that the change in attitude has not been categorical or definitive as they were not observed to be completely convinced as to the use of applying this methodology with their own means.

Finally, Bartolomé Dezerega, INTEC's director, emphasised that this type of project supported by the IDRC is highly desirable for INTEC as it represents an opportunity to participate in technologically more developed projects, in contrast with most of the projects they carry out in which short term pressure and the need for self-financing imposed by the government prevent more ambitious goals being drawn up.

Moreover, Mr. Dezerega considered that the IDRC's role has been interesting, and on occasions decisive in stimulating the productive sector to invest in technology, since "the industrialist sees the IDRC as having an aura of prestige and seriousness". Furthermore, he recommended that this type of project keep as closely as possible to industrial reality.

As in the case of the coffee project, the impact assessment instrument was applied to Mr. Simian, Dr. Edwardson and the assessor. The most relevant results of this evaluation are the following:

As in the previous case, the most significant impact was on the research group that considered it had greatly benefitted by obtaining a high degree of training in the methodology and on how to work with small enterprises. Unfortunately, this training was mainly given to the technicians who worked on the project (and are now working in large enterprises) since the impact on the ability of human resources was very slight. This was due to the fact that training programmes were neither designed nor implemented, an aspect that should have been contemplated in accordance with the original methodology.

The technical and economic impact was little significant in spite of the fact that the technical group that developed the project was very competent, as the project really had only a small component of immediate technical problem solving. This, in turn, certainly influenced the small impact on the organization and entrepreneurial spirit of the bakers, since even though they were convinced of the worth of knowing the factors affecting quality, they did not come up with concrete, short term solutions which is somewhat dismotivating.

It could also be observed that the social and environmental impact was slight since these variables were hardly tackled at all.

As in the previous case, there was in this project a marked absence of promotion among organizations that could continue the support. This case presented an even more serious characteristic: Chilean liberal policies involve a very low level of support to industry and technological development.

c) CHEESE MAKING - ECUADOR - INSOTEC

Nelson Oleas, technician in charge of the project, collaborated in this visit. The advance achieved and application of the methodology were discussed with him.

The following day was devoted to visiting several cheese factories that participated in the benefits of this project:

- Productos Lácteos Super: Mr. Altamirano (Mulaló)
- Quesería Latacunga: Mr. César Pérez (Mulaló)
- Finca de las Sritas. Gutiérrez (Cotopaxi)
- Delilacpy: Mr. Germán Pozo (Salcedo)

Finally, on the third day, Mr. Fernando Fernández, Technical Director of INSOTEC, was interviewed.

This project hardly touched on the application of the process improvement technology as it was limited to making a diagnosis (on the request of the beneficiaries).

Some important results were obtained from a very extensive diagnosis of the quality of the milk used and the cheese produced. The following can be mentioned:

- The achievement of a union association that has begun to carry out joint actions to transport the finished product to the consumption centres.

- Given the low quality of the cheeses detected by the project, some manufacturers have begun to be concerned about making better products.

- In an unprogrammed way, recommendations were made to decrease losses, increase cleanliness and use by-products.

- A high level of motivation was generated in some producers.

- Several entrepreneurs contracted technicians from the Centro de Adiestramiento Lechero (Milk Training Centre) to improve their production.

These results were encouraging but the project has not been followed up and, in several cases, the level of motivation has begun to fall.

For example, Mr. Altamirano was enthusiastic about having access to quality control but complained that the supposed union association had done nothing ("words get you nowhere").

Mr. César Pérez, leader of the union association, mentioned that some producers now understand what analyses are, which is undoubtedly an advance. However, he thought there would be many problems with the union association because people were not really involved and had a passive attitude, hoping everything would be solved for them. Mr. Pérez also commented that one of the biggest problems of this type of enterprise is that there is no price administration.

Mr. Pérez's attitude reflected a certain lack of willingness to perform concrete actions. He even blamed INSOTEC for several unfinished activities, for example, the design of a quality control laboratory.

Two farms were then visited that could be considered model farms as a great entrepreneurial and innovative spirit could be seen in the owners. Both the Misses Gutiérrez and Mr. Pozo were so motivated by the project that they have made investments to

improve quality, diversify their products and improve sales. It is of note that in people like this a small stimulus is sufficient to yield good results.

Mr. Fernando Fernández of INSOTEC was very pleased with project as it has led to greater communication with the small scale industry in this sector. It goes without saying that he was also satisfied with having obtained IDRC financing and wished to obtain an extension to continue the project.

Since the project was limited to a diagnosis, its tangible results are of little significance. It would probably have been possible to search for some concrete technical solutions, but statistical criteria were not taken into account to select a small but reliable sample, and so a great deal of effort was spent on extracting data from a sample that was much too large.

Undoubtedly, the learning obtained by the researchers was important. Again, however, since training aspects were practically left out, the application of the knowledge generated depends totally on INSOTEC's having adequate financing to continue this project. If this is not provided, the project's great achievement (motivation of the entrepreneurs) will be irremediably lost. An unmistakable sign of this is that the union association has not been formalised.

GENERAL ASSESSMENT OF THE APPLICATION OF THE METHODOLOGY

As a result of the field work and the various interviews held within the framework of this consultation project, it has been possible to identify some deficiencies in the application of the process improvement technique for small scale food enterprises.

First, it should be mentioned that none of the groups kept sufficiently close to what was stipulated in document IDRC - Ts - 48e with respect to the identification of problem areas and the priority they should be given. The techniques described in the document (checklists, charting, work sampling, Pareto's law, economic analysis) are methodological instruments that have been successfully used for years in Industrial Engineering. Indeed

Figure 5 (page 31) graphically represents the process of problem identification in a clear, understandable way. However, the researchers on the pilot projects did not make an exhaustive search of the different sources of the problems. This was together with the low degree to which creativity fostering techniques were addressed in the projects (see Table 1).

All this seems to indicate that once the researchers believe in an idea, they devote themselves to it heart and soul and are not prepared to abandon it. Thus, they formed an "a priori" conception of the problem to be solved without considering that there were probably higher priority areas for the process improvement. All this, of course, demerits other quicker, cheaper possible solutions which would have greater impact.

Table 1. Methods to foster creativity.

Drawn up by G. Patzak; 1983

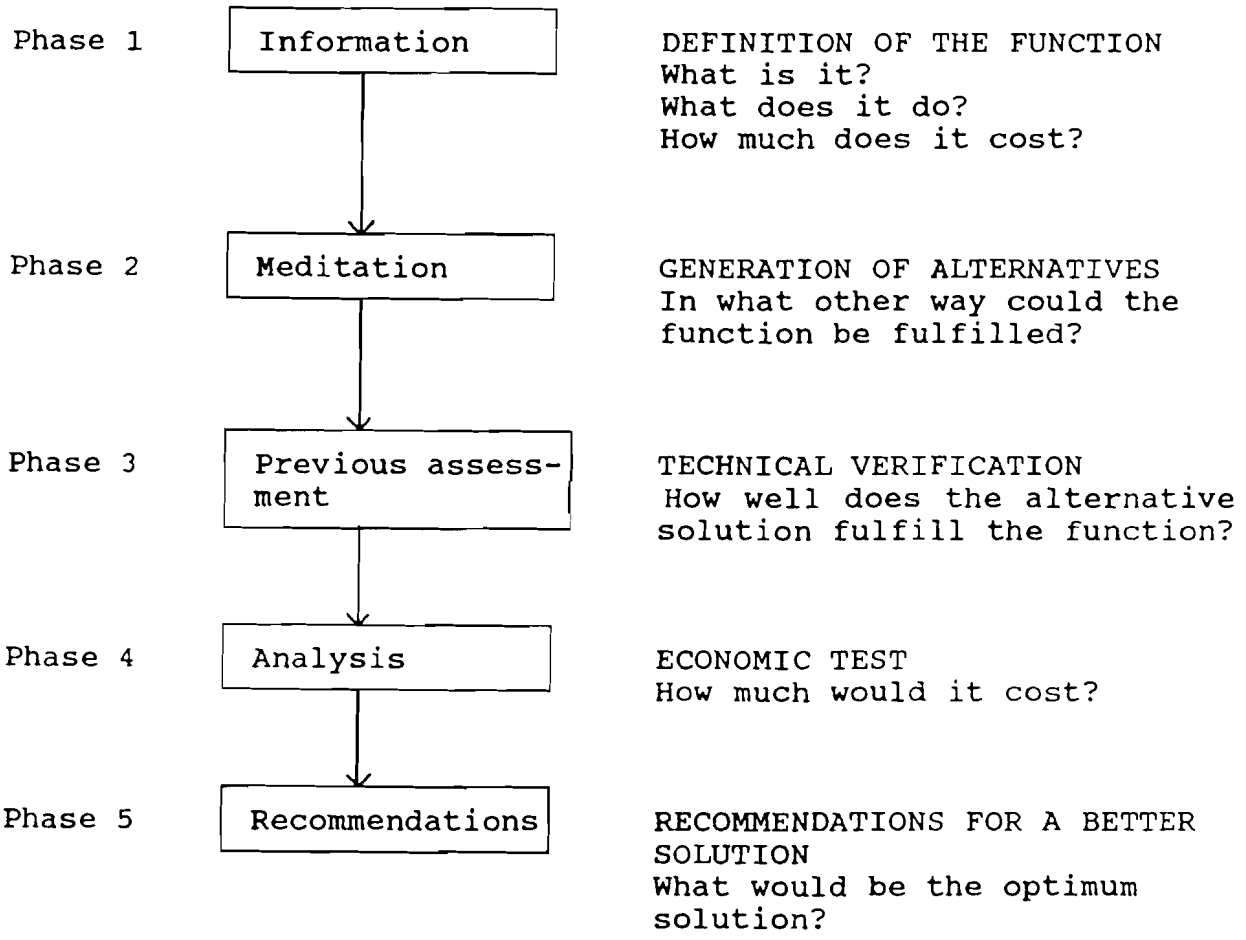
Group Creativity	Individual Creativity
- Brainstorming and its variants	- Lists of attibutes
- Brainwriting and its variants	- Analysis of functions (list of alternatives)
- Synektik and its variants	- Morphological trees, ideas matrix
- Delphi techniques	- Analogies Bionics
	- Broadening of the function Progressive abstraction Liberation of the field of search
	- Relevance trees.

In this sense, the author recommends training the researchers in the creative search for solutions to problems. Annex 3 presents the material used by INFOTEC in Mexico for a two day seminar on creativity.

Another technique that should be exploited is the so-called "Value Analysis and engineering" based on the analysis of basic functions and the creative search for alternatives to fulfill these functions. Chart 1 schematically shows the process of value analysis.

Chart 1. The value analysis process.

Drawn up by J.L. Solleiro (1983)



Another significant problem is the lack of a systematic approach to tackling the process improvement, in spite of the fact that the process improvement technique stems from recognition that the different functions of an enterprise cannot be analysed in isolation.

Most of the researchers concentrated their analysis efforts on inputs and on some parts of the process. There was no sign of their having observed aspects like internal organization, the managing and motivation of human resources, the selection and/or design of better equipment and, probably the most serious, they did not approach the problem of sales, product handling, packaging aspects and elimination of waste.

This partial vision can lead to neglect of areas in which improvements can bring much more positive impacts on the beneficiary groups. For this reason, it is essential that the technique be applied with an integral vision.

In short, it is very important to bear in mind that process improvement can occur at any stage, from the reception of raw materials to the presentation of the end product.

Another contribution of the systematic focus is to approach the analysis and solution of problems with a heuristic vision in which the search for solutions stems from a synthesis of the initial conditions, and if these show problematic or little satisfactory aspects, a repetitive process of searching for solutions in undertaken. Chart 2 shows a flow chart of this process.

In SYNTHESIS II in Chart 2, the generation of alternatives can be based on the following approaches:

a) Improvement of traditional technologies ("blending"). This approach is based on the incorporation of advanced technologies to improve output in those parts of the process that form bad bottlenecks.

b) "Backwards" adaptation of modern technologies ("downgrading"). In this case, it is possible to think of the incorporation of modern technologies that have been adapted to local conditions in an attempt to make the processes simpler, less capital intensive and perhaps with a slightly reduced output but that nevertheless meets the demand of the market in question.

c) Development of new technology. This alternative requires a larger dose of creativity and innovative spirit. It can generate the most adequate results but demands a high degree of investment and long periods for development. Be that as it may, this approach should point towards an optimum combination of scarce and abundant factors of production, according to the conditions in the country or region in question.

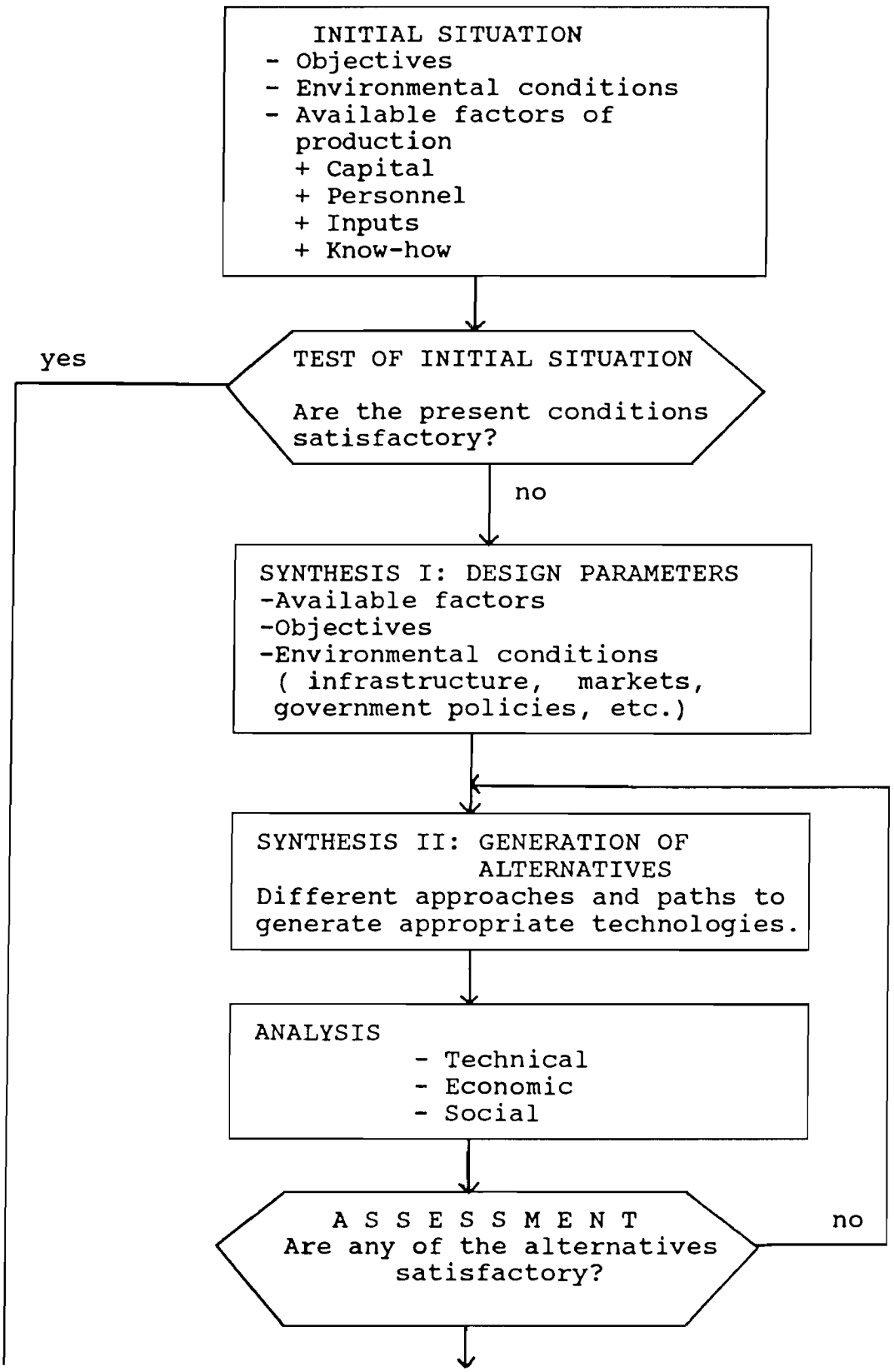
d) Use of existing (or even used) machinery and installations. Many technological problems in the processes are due more to the equipment than the variables in the process itself. For this reason, this may be a very quick solution to improve output. It is worth mentioning here that this option was little studied in the projects analysed and that it is undoubtedly an area that needs to be strengthened as regards equipment selection and design.

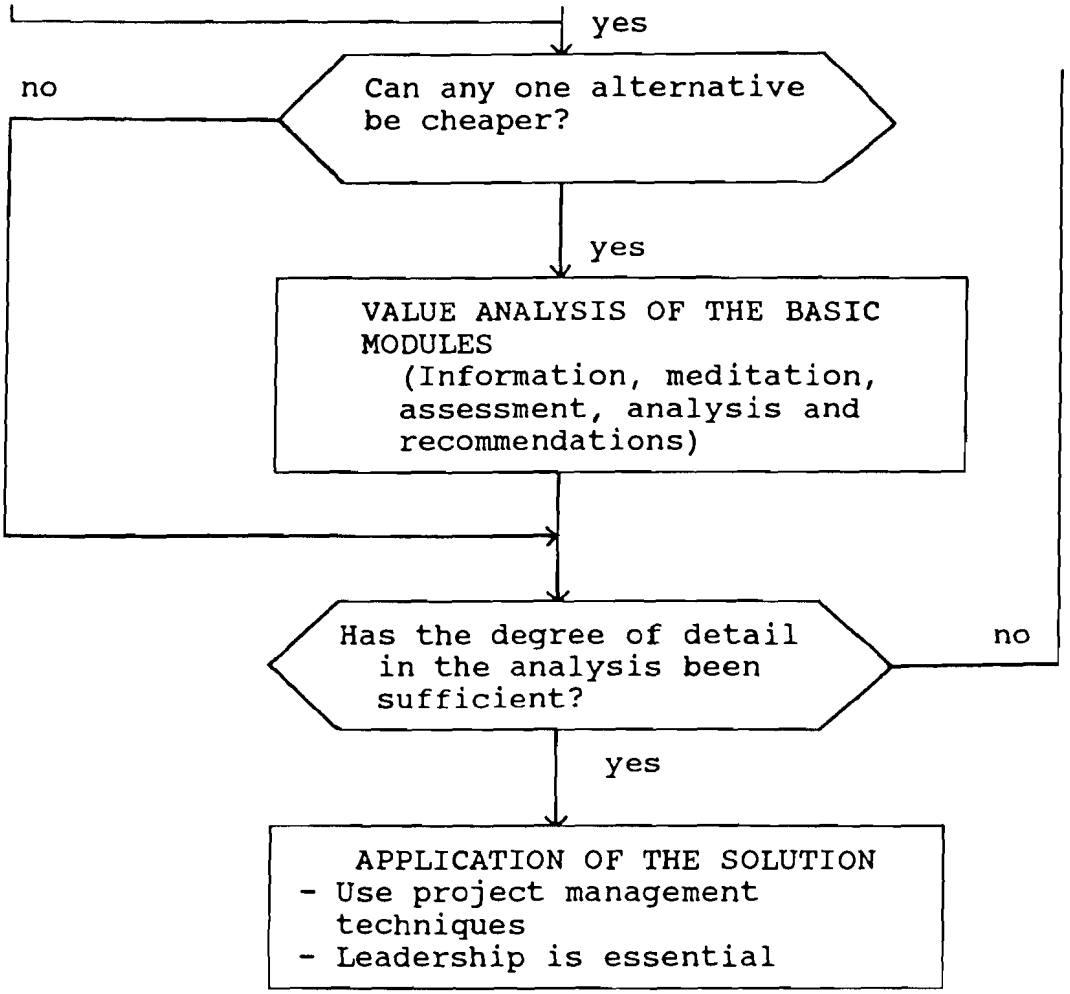
e) A combination of all the above mentioned approaches can also be presented in an attempt to modify products, materials, production processes, control systems, the form of organization and level of the workers, applying differentiated approaches.

It is convenient to point out that in order to adequately provide a systematic vision for the application of the process improvement technique the work of a project leader who can handle a multiplicity of variables is essential.

Chart 2. Process of generation of appropriate technological solutions

Drawn up by J.L. Solleiro (1983)





Finally, another problem observed was that the project was excessively long and, in two of the three cases, the results were rather too academic. In this way, it is very difficult to make a small entrepreneur, subject to strong short term pressures, become involved in this type of project.

It would then be advisable in future projects to look for an adequate balance between the search for quick, simple, concrete, cheap solutions and the more conscientious analyses needed for solutions to more important problems which need more time. If not, we do not think it will be feasible to motivate the small entrepreneur to participate.

The lack of promotion by the researchers undoubtedly affects the possibility of applying this type of techniques on a large scale. Neither the authorities, nor the union associations, nor the development institutions will be able to channel funds for this type of project if they do not know them well enough to be convinced of their worth.

POTENTIAL OF THE PROCESS IMPROVEMENT TECHNIQUE.

The contents of the previous chapter in no way mean that the methodology should be abandoned. On the contrary, in spite of everything, and the natural deficiencies inherent in the application of a technique at pilot level, some tangible results were obtained and ways of contributing more quickly and economically to the benefit of small enterprises were identified.

Even when translated into a philosophy of problem analysis (since it is a disciplined analysis and action system), this methodology can undoubtedly lead the researchers to an optimum planning of the applied research and in this way the research will surely be directed at satisfying very concrete existing needs, thus substantially increasing the probability of success of innovative projects.

It must not be forgotten that according to Donald Marquis's classical analysis (The Anatomy of Successful Innovations), three quarters of the successful innovative projects originated in the recognition of a demand or necessity, and the process improvement technique provides us with very valuable tools to identify this need. If the researcher were to bear in mind the questions mentioned in document IDRC-TS 48e (page 29) - what, why, who, how, where and when - it would be practically certain that his role in problem solving, where identificacion is the most important step, would be much more relevant.

Furthermore, the correct application of the methodology can lead to solutions to a set of problems that has been barely touched upon, as is the case of the development of simple, economical equipment for small scale agroindustries and food enterprises.

Moreover, as the process improvement technique generates technical solutions for small entrepreneurs, it will be able to contribute to the entrepreneurs deciding to participate in more complex technological adventures, such as for example the incorporation of automated measurement and control systems, the use of microcomputers not only in administration but also in process handling.

RECOMMENDATIONS FOR THE FUTURE APPLICATION OF THE PROCESS IMPROVEMENT METHODOLOGY

The most important suggestion to begin with is probably the training of project leaders in the correct application of the process improvement approach. In this sense, it is essential to design a course that takes into account all the elements of the methodology, from inputs to the products and their destiny and that also has a strong practical component in which different creativity exercises are performed. (See annex 3)

It would also be convenient to incorporate the methodology into projects which are underway at present. During the field work, the possibility was studied of applying the technique in the banana and fish processing projects. However, it did not seem very adequate to try our luck with these projects. In the first case, the feasibility of continuing with the project was not clear since ICAITI's proposition of working with a small cooperative presents a large number of questions that would have to be answered before continuing investing.

In the case of fish processing, there is a record of failure and all seems to indicate that the researchers are trying to justify and finance, through a technological project, objectives of a political character, involving social mobilization.

However, there must be other projects in the post-production area into which the technique can be incorporated but with very pragmatic objectives.

Of course, the determination of these objectives must be clearly and correctly directed to an increase in productivity. Furthermore, it is important to handle quantifiable output assessment parameters of universal value (recognized as technical performance parameters) and which have a multifactorial perspective *. The most common parameters that can be combined to assess output are standard costs, prices and technical parameters that quantify the output of the product or process (velocity of the reaction, yield of the microorganism, fermentation time, etc.).

The incorporation of this type of approach into the assessment will avoid subjective opinions and lead to better project follow up.

It is important that there is closer follow up of this type of project by the IDRC (especially when getting projects underway) and that it is occasionally supported by outside assessors but based on the concrete technical parameters defined above.

For this follow up, it is also useful to contemplate the research project as a system in which the different types of results it may generate are assessed in such a way that the group benefitted be as wide as possible. The ideal system assesses quality, quantity and cost; it is simple and emphasises the results rather than the people **. Figure 2 shows this systems approach.

It is also important to recommend that there be much stricter control in complying with terms and costs as it is unacceptable to the end user that the project is delayed for several years without providing him with practical results and that project costs greatly exceed the benefits obtained.

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* Chew, Bruce: No-nonsense Guide to Measuring Productivity. Harvard Business Review. Jan-Feb, 1988.

** Brown M. and Svenson R.: Measuring R & D Productivity; Research - Technology Management; July - Aug. 1988.

Finally, to complement the above, it would be useful if the IDRC made known some selected information on the application of modern industrial engineering techniques in improving the management of agroindustrial and food enterprises. To this end, it would also be advisable for the IDRC to support some research projects on the process improvement technique itself and as a result of this produce some application manuals and materials that could be used in the training suggested in previous sections.

BIBLIOGRAPHY

- Armstrong, Joe E.; Strategies for Conducting Technology Assessments; Westview Special Studies in Science, Technology, and Public Policy, 1980.

- Boroush et al., eds.; Technology Assessments; Creative Futures. series vol. 5; Elsevier North, Holland; 1980.

- Braun, Ernest; et al.; Assessment of Technological Decisions-Case Studies; Butterworths; London-Boston; 1979.

- Lantos, Peter, R.; Market - Oriented R&D ;Chemtech; March, 1989.

- Economic and Technical Information on Typical Industries. AID - Agency for International Development; USA; Industry Profiles.

- Japan Consulting Institute; How to Start Smaller Industries; Series R1; March, 1978. Series R3; March, 1980.

- Good Guidance Gladly Given to Small and Minority-owned Firms; Foreign Agriculture, vol. 26 No. 9; Sept. 1988.

- Patzak, G.: Systemtechnik - Planning Komplexer innovativer Systeme, Springer-Verlag; 1982.

- Emmanuel, A.: Appropriate or Underdeveloped Technology?; John Wiley & Sons; 1982.

- Miles, L. D.: Techniques of Value Analysis and Engineering; Mc Graw-Hill; 1972.

- Roberts, E. (ed.): Generating Technological Innovation; Oxford University Press, 1987.

- Tushman, M.; Moure, W.: Readings in the Management of Innovation; Pitman Publishing Inc.; 1982.

- Cadem et al: Administración de Proyectos de Innovación Tecnológica; Ed. Gernika, 1986.

- Solleiro, J.L.: Vorgehen zur Entwicklung, Auswahl und Einsatz angepasster Technologien fur Entwicklungslander; Dissertation; tu-wien; Vienna, 1983.

- Chew, W.; No-Nonsense Guide to Productivity; Harvard Business Review; Jan-Feb 1988.

- Brown, M. and Svenson, R.: Measuring R&D Productivity; Research-Technology Management; July-Aug. 1988.

- Manual de Administración para la pequeña y mediana empresa en México; Editorial Osar; 1987.

CAFE - GUATEMALA - IDRC - ICAITI

HOJA DE EVALUACION DEL IMPACTO DEL PROYECTO

Con el objeto de precisar el impacto que ha tenido el proyecto sobre diferentes variables y, a partir de ello, determinar la orientación de futuros programas de investigación, rogamos a usted responder lo siguiente.

	Investigador	Funcionario IDRC	Evaluador	Promedio
1. Impacto económico.				
1.1 El aumento de la productividad y/o disminución de costos fue:	2	2	1	1.7
1.2 El proyecto permitió ampliar y/o diversificar el mercado para el/los producto(s) de la empresa/cooperativa.	0	2	1	1
1.3 El proyecto contribuyó a mejorar la salud financiera de la empresa/cooperativa, ya que permitió pagar créditos y dejó un nivel de liquidez adecuado.	3	2	2	2.4
1.4 Las inversiones realizadas con el proyecto tienen un nivel de rentabilidad.	3	2	1	2
1.5 Gracias al proyecto hemos logrado un aumento de valor agregado ...	2	2	1	1.7
1.6 El proyecto ha contribuído para el mejor aprovechamiento de nuestra producción primaria (agrícola a pecuaria).	2	3	2	2.4
				1.86

1.7 Otros factores económicos, favor de enunciarlos.

0 Insignificante

3 Sustancial / significativamente

	Investigador	Funcionario IDRC	Evaluador	Promedio
2. Impacto técnico.				
2.1 El proyecto nos ha permitido mejorar el uso de nuestras fuentes de energía (combustibles, leña, etc.) de manera ...	2	2	1	1.7
2.2 Hemos logrado economías gracias al uso de materiales disponibles en la región para ejecutar las recomendaciones del proyecto.	3	3	3	3
2.3 La calidad de nuestros productos aumentó de manera	2	2	0	1.4
2.4 Gracias a las recomendaciones del proyecto, hemos logrado una mayor confiabilidad de nuestros equipos y maquinaria, pues nuestros conocimientos sobre mantenimiento aumentaron de manera	3	2	1	2
2.5 Nuestra capacidad para diseñar modificaciones y mejoras al equipo y al proceso aumentó de manera	3	1	1	1.7
2.6 Nuestras pórdidas de materia prima y producto en los almacenes disminuyeron	2	3	2	2.4
2.7 Las pórdidas en el proceso de producción disminuyeron	2	3	2	2.4
2.8 Nuestra capacidad de almacenaje y transporte de productos y materias primas aumento	1	2	1	1.4
2.9 Otros aspectos técnicos no contemplados, favor de enunciarlos.				
				2.25
3. Impacto social.				
3.1 Gracias al proyecto, el nivel de ingreso de nuestros trabajadores aumentó.	3	2	0	1.7
3.2 La seguridad en las tareas y en los diferentes puestos de trabajo aumentó.	2	-	0	1

	Investigador	Funcionario IDRC	Evaluador	Promedio
3.3 Los trabajadores se sienten mas motivados y tienen un nivel de satisfacción mayor, pues la contribución del proyecto fue	2	1	2	1.7
3.4 La comunicación entre trabajadores, supervisores y gerencia aumentó de manera	-	1	1	1
3.5 Los trabajadores han aumentado sus contribuciones y aportan ideas para mejorar de manera	2	1	1	1.4
3.6 Las tócnicas nuevas se han adaptado a la forma de organización y de trabajar de manera	3	2	1	2
3.7 Algún otro impacto social no contemplado, favor de enunciarlo				
				1.46
4. Impacto ambiental.				
4.1 El proyecto ha contribuído a evitar problemas de contaminación en nuestra región/ambiente.	0	0	0	0
4.2 El proyecto ha ayudado a conservar recursos no renovables.	2	0	0	0.7
4.3 Otros efectos, favor de enunciarlos.				
				0.35
5. Impacto sobre la organización y el espíritu empresarial.				
5.1 El proyecto contribuyó a mejorar los procedimientos administrativos y la organización de los procesos de producción.	1	1	1	1
5.2 El proyecto contribuyó a tener mejores controles contables y presupuestales.	1	2	1	1.4
5.3 El proyecto contribuyó a mejorar nuestra organización interna.	1	2	1	1.4

	Investigador	Funcionario II	Evaluador	Promedio
5.4 El proyecto ha traído consigo un cambio de actitud en la gerencia. Por ejemplo, hoy estamos convencidos de la necesidad de invertir en cambios tócnicos y administrativos que mejoren nuestra productividad.	1	2	1	1.4
5.5 El proyecto influyó en que la gerencia apoye programas de capacitación.	3	0	2	1.7
5.6 Gracias al proyecto, nuestra empresa/cooperativa busca sistemáticamente alternativas de desarrollo.	2	1	1	1.4
5.7 Favor de enunciar otros impactos administrativos de consideración.				
				1.38
6. Impacto sobre la capacidad de asimilación de tecnología.				
6.1 El proyecto nos ha hecho evidente la necesidad de contar con un archivo tócnico completo.	-	0	0	0
6.2 Mediante el proyecto se han promovido programas de capacitación a todos los niveles.	2	1	1	1.4
6.3 Gracias al proyecto hay una actitud propicia al cambio y a la búsqueda de innovaciones.	2	2	1	1.7
6.4 Otros, favor de enunciarlos				
				1.03
7. Impacto sobre la capacidad de los recursos humanos				
7.1 Los trabajadores dominan las tócnicas de operación y comprenden las frases del proceso que les corresponden. A esto el proyecto contribuyó de manera.	3	1	1	1.7
7.2 El personal de mantenimiento está capacitado, tanto para hacer reparaciones, como para llevar un programa de mantenimiento preventivo.	-	-	-	-

	Investigador	Funcionario IDRC	Evaluador	Promedio
7.3 La gerencia y los supervisores manejan tócnicas de administración y están dispuestos a correr los riesgos del cambio.	-	1	1	1
7.4 Favor de enunciar otros factores.				
				1.35
8. Impacto político.				
8.1 El proyecto ha conducido al gobierno a considerar la implantación, a nivel nacional/sectorial, programas similares.	0	0	0	0
8.2 Diversas dependencias están dispuestas a canalizar fondos para programas similares.	0	1	1	0.7
8.3 Los organismos internacionales desean seguir apoyando proyectos de este tipo, con base en sus resultados.	-	1	1	1
8.4 Favor de citar otro tipo de impactos políticos.				
				0.56
9. Impacto sobre el grupo de investigación				
9.1 Se desarrollaron metodologías novedosas que pueden aplicarse en otros ámbitos.	3	3	1	2.4
9.2 Los resultados del proyecto contribuyen al prestigio personal y/o institucional.	3	3	2	2.7
9.3 El proyecto trajo consigo un aprendizaje que puede considerarse.	3	3	2	2.7
9.4 Favor de citar los diferentes resultados del proyecto y comentar su relevancia.				
				2.6

PANADERIAS - CHILE - IDRC - INTEC

HOJA DE EVALUACION DEL IMPACTO DEL PROYECTO

Con el objeto de precisar el impacto que ha tenido el proyecto sobre diferentes variables y, a partir de ello, determinar la orientación de futuros programas de investigación, rogamos a usted responder lo siguiente.

1. **Impacto económico.**	Investigador	Funcionario IDRC	Evaluador	Promedio
1.1 El aumento de la productividad y/o disminución de costos fue:	2	1	1	1.4
1.2 El proyecto permitió ampliar y/o diversificar el mercado para el/los producto(s) de la empresa/cooperativa.	0	0	0	0
1.3 El proyecto contribuyó a mejorar la salud financiera de la empresa/cooperativa, ya que permitió pagar créditos y dejó un nivel de liquidez adecuado.	2	1	1	1.4
1.4 Las inversiones realizadas con el proyecto tienen un nivel de rentabilidad.	2	2	1	1.7
1.5 Gracias al proyecto hemos logrado un aumento de valor agregado ...	2	0	1	1
1.6 El proyecto ha contribuído para el mejor aprovechamiento de nuestra producción primaria (agrícola a pecuaria).	-	-	-	-
				1.1

1.7 Otros factores económicos, favor de enunciarlos.

0 Insignificante

3 Sustancial / significativamente

	Investigador	Funcionario ID	Evaluador	Promedio
2. Impacto técnico.				
2.1 El proyecto nos ha permitido mejorar el uso de nuestras fuentes de energía (combustibles, leña, etc.) de manera ...	0	2	1	1
2.2 Hemos logrado economías gracias al uso de materiales disponibles en la región para ejecutar las recomendaciones del proyecto.	-	2	-	2
2.3 La calidad de nuestros productos aumentó de manera	-	2	0	1
2.4 Gracias a las recomendaciones del proyecto, hemos logrado una mayor confiabilidad de nuestros equipos y maquinaria, pues nuestros conocimientos sobre mantenimiento aumentaron de manera	2	3	1	2
2.5 Nuestra capacidad para diseñar modificaciones y mejoras al equipo y al proceso aumentó de manera	2	2	2	2
2.6 Nuestras pórdidas de materia prima y producto en los almacenes disminuyeron	2	3	1	1.7
2.7 Las pórdidas en el proceso de producción disminuyeron	2	2	1	1.7
2.8 Nuestra capacidad de almacenaje y transporte de productos y materias primas aumento	-	0	1	0.5
2.9 Otros aspectos tócnicos no contemplados, favor de enunciarlos.				
				1.48
3. Impacto social.				
3.1 Gracias al proyecto, el nivel de ingreso de nuestros trabajadores aumentó.	0	0	0	0
3.2 La seguridad en las tareas y en los diferentes puestos de trabajo aumentó.	0	0	0	0

	Investigador	Funcionario II	Evaluador	Promedio
3.3 Los trabajadores se sienten mas motivados y tienen un nivel de satisfacción mayor, pues la contribución del proyecto fue	1	1	1	1
3.4 La comunicación entre trabajadores, supervisores y gerencia aumentó de manera	0	2	0	0.7
3.5 Los trabajadores han aumentado sus contribuciones y aportan ideas para mejorar de manera	-	2	0	1
3.6 Las tócnicas nuevas se han adaptado a la forma de organización y de trabajar de manera	2	1	-	1.5
3.7 Algún otro impacto social no contemplado, favor de enunciarlo				
				0.7
4. Impacto ambiental.				
4.1 El proyecto ha contribuido a evitar problemas de contaminación en nuestra región/ambiente.	-	-	0	0
4.2 El proyecto ha ayudado a conservar recursos no renovables.	-	1	0	0.5
4.3 Otros efectos, favor de enunciarlos.				
				0.25
5. Impacto sobre la organización y el espiritu empresarial.				
5.1 El proyecto contribuyó a mejorar los procedimientos administrativos y la organización de los procesos de producción.	2	1	1	1.4
5.2 El proyecto contribuyó a tener mejores controles contables y presupuestales.	2	0	0	0.7
5.3 El proyecto contribuyó a mejorar nuestra organización interna.	-	2	1	1.5

	Investigador	Funcionario II	Evaluador	Promedio
5.4 El proyecto ha traido consigo un cambio de actitud en la gerencia. Por ejemplo, hoy estamos convencidos de la necesidad de invertir en cambios tócnicos y administrativos que mejoren nuestra productividad.	1	1	1	1
5.5 El proyecto influyó en que la gerencia apoye programas de capacitación.	1	2	1	1.4
5.6 Gracias al proyecto, nuestra empresa/cooperativa busca sistemáticamente alternativas de desarrollo.	1	1	1	1
5.7 Favor de enunciar otros impactos administrativos de consideración.				
				1.16
6. Impacto sobre la capacidad de asimilación de tecnologia.				
6.1 El proyecto nos ha hecho evidente la necesidad de contar con un archivo tócnico completo.	2	1	2	1.7
6.2 Mediante el proyecto se han promovido programas de capacitación a todos los niveles.	1	1	1	1
6.3 Gracias al proyecto hay una actitud propicia al cambio y a la búsqueda de innovaciones.	1	1	1	1
6.4 Otros, favor de enunciarlos				
				1.23
7. Impacto sobre la capacidad de los recursos humanos				
7.1 Los trabajadores dominan las tócnicas de operación y comprenden las frases del proceso que les corresponden. A esto el proyecto contribuyó de manera.	1	1	1	1
7.2 El personal de mantenimiento está capacitado, tanto para hacer reparaciones, como para llevar un programa de mantenimiento preventivo.	-	-	0	0

	Investigador	Funcionario ID	Evaluador	Promedio
7.3 La gerencia y los supervisores manejan tócnicas de administración y están dispuestos a correr los riesgos del cambio.	1	1	1	1
7.4 Favor de enunciar otros factores.				
				1.35
8. Impacto político.				
8.1 El proyecto ha conducido al gobierno a considerar la implantación, a nivel nacional/sectorial, programas similares.	-	0	0	0
8.2 Diversas dependencias están dispuestas a canalizar fondos para programas similares.	2	1	2	1.7
8.3 Los organismos internacionales desean seguir apoyando proyectos de este tipo, con base en sus resultados.	-	1	1	1
8.4 Favor de citar otro tipo de impactos políticos.				
				0.9
9. Impacto sobre el grupo de investigación				
9.1 Se desarrollaron metodologías novedosas que pueden aplicarse en otros ámbitos.	3	3	2	2.7
9.2 Los resultados del proyecto contribuyen al prestigio personal y/o institucional.	3	3	2	2.7
9.3 El proyecto trajo consigo un aprendizaje que puede considerarse.	3	3	3	3
9.4 Favor de citar los diferentes resultados del proyecto y comentar su relevancia.				
				2.8

PRODUCCION DE QUESOS - ECUADOR - IDRC - INSOTEC

HOJA DE EVALUACION DEL IMPACTO DEL PROYECTO

Con el objeto de precisar el impacto que ha tenido el proyecto sobre diferentes variables y, a partir de ello, determinar la orientación de futuros programas de investigación, rogamos a usted responder lo siguiente.

	Investigador	Funcionario IDRC	Evaluador	Promedio
1. **Impacto económico.**				
1.1 El aumento de la productividad y/o disminución de costos fue:	-	-	-	-
1.2 El proyecto permitió ampliar y/o diversificar el mercado para el/los producto(s) de la empresa/cooperativa.	1	-	-	1
1.3 El proyecto contribuyó a mejorar la salud financiera de la empresa/cooperativa, ya que permitió pagar créditos y dejó un nivel de liquidez adecuado.	-	-	-	-
1.4 Las inversiones realizadas con el proyecto tienen un nivel de rentabilidad.	2	-	-	2
1.5 Gracias al proyecto hemos logrado un aumento de valor agregado ...	-	-	-	-
1.6 El proyecto ha contribuido para el mejor aprovechamiento de nuestra producción primaria (agrícola a pecuaria).	2	1	1	1.4
				1.46

1.7 Otros factores económicos, favor de enunciarlos.

0 Insignificante

3 Sustancial / significativamente

	Investigador	Funcionario ID	Evaluador	Promedio
2. Impacto tócnico.				
2.1 El proyecto nos ha permitido mejorar el uso de nuestras fuentes de energia (combustibles, leña, etc.) de manera ...	1	-	-	1
2.2 Hemos logrado economias gracias al uso de materiales disponibles en la región para ejecutar las recomendaciones del proyecto.	-	-	-	-
2.3 La calidad de nuestros productos aumentó de manera	2	1	1	1.4
2.4 Gracias a las recomendaciones del proyecto, hemos logrado una mayor confiabilidad de nuestros equipos y maquinaria, pues nuestros conocimientos sobre mantenimiento aumentaron de manera	1	1	0	0.7
2.5 Nuestra capacidad para diseñar modificaciones y mejoras al equipo y al proceso aumentó de manera	1	1	1	1
2.6 Nuestras pórdidas de materia prima y producto en los almacenes disminuyeron	-	-	1	1
2.7 Las pórdidas en el proceso de producción disminuyeron	1	-	1	1
2.8 Nuestra capacidad de almacenaje y transporte de productos y materias primas aumento	2	-	1	1.5
2.9 Otros aspectos tócnicos no contemplados, favor de enunciarlos.				
				1.08
3. Impacto social.				
3.1 Gracias al proyecto, el nivel de ingreso de nuestros trabajadores aumentó.	-	-	-	
3.2 La seguridad en las tareas y en los diferentes puestos de trabajo aumentó.	-	-	-	

	Investigador	Funcionario II	Evaluador	Promedio
3.3 Los trabajadores se sienten mas motivados y tienen un nivel de satisfacción mayor, pues la contribución del proyecto fue	2	1	0	1
3.4 La comunicación entre trabajadores, supervisores y gerencia aumentó de manera	-	1	1	1
3.5 Los trabajadores han aumentado sus contribuciones y aportan ideas para mejorar de manera	3	0	0	1
3.6 Las tócnicas nuevas se han adaptado a la forma de organización y de trabajar de manera	-	1	-	1
3.7 Algún otro impacto social no contemplado, favor de enunciarlo				
				1.0
4. Impacto ambiental.				
4.1 El proyecto ha contribuido a evitar problemas de contaminación en nuestra región/ambiente.	-	0	0	0
4.2 El proyecto ha ayudado a conservar recursos no renovables.	1	0	0	0.4
4.3 Otros efectos, favor de enunciarlos.				
				0.2
5. Impacto sobre la organización y el espiritu empresarial.				
5.1 El proyecto contribuyó a mejorar los procedimientos administrativos y la organización de los procesos de producción.	2	1	1	1.4
5.2 El proyecto contribuyó a tener mejores controles contables y presupuestales.	1	0	1	0.7
5.3 El proyecto contribuyó a mejorar nuestra organización interna.	3	0	1	1.4

	Investigador	Funcionario ID	Evaluador	Promedio
5.4 El proyecto ha traído consigo un cambio de actitud en la gerencia. Por ejemplo, hoy estamos convencidos de la necesidad de invertir en cambios tócnicos y administrativos que mejoren nuestra productividad.	2	2	1	1.7
5.5 El proyecto influyó en que la gerencia apoye programas de capacitación.	1	0	0	0.4
5.6 Gracias al proyecto, nuestra empresa/cooperativa busca sistemáticamente alternativas de desarrollo.	2	1	1	1.4
5.7 Favor de enunciar otros impactos administrativos de consideración.				
Organización gremial de productores	3	-	2	2.5
				1.36
6. Impacto sobre la capacidad de asimilación de tecnología.				
6.1 El proyecto nos ha hecho evidente la necesidad de contar con un archivo tócnico completo.	2	1	1	1.4
6.2 Mediante el proyecto se han promovido programas de capacitación a todos los niveles.	2	0	0	0.7
6.3 Gracias al proyecto hay una actitud propicia al cambio y a la búsqueda de innovaciones.	2	1	1	1.4
6.4 Otros, favor de enunciarlos				
				1.16
7. Impacto sobre la capacidad de los recursos humanos				
7.1 Los trabajadores dominan las tócnicas de operación y comprenden las frases del proceso que les corresponden. A esto el proyecto contribuyó de manera.	1	0	1	0.7
7.2 El personal de mantenimiento está capacitado, tanto para hacer reparaciones, como para llevar un programa de mantenimiento preventivo.	-	-	0	0

	Investigador	Funcionario II	Evaluador	Promedio
7.3 La gerencia y los supervisores manejan tócnicas de administración y están dispuestos a correr los riesgos del cambio.	-	1	1	1
7.4 Favor de enunciar otros factores.				
				0.56
8. Impacto político.				
8.1 El proyecto ha conducido al gobierno a considerar la implantación, a nivel nacional/sectorial, programas simil :es.	-	0	0	0
8.2 Diversas dependencias están dispuestas a canalizar fondos para programas similares.	2	1	1	1.4
8.3 Los organismos internacionales desean seguir apoyando proyectos de este tipo, con base en sus resultados.	-	1	0	0.5
8.4 Favor de citar otro tipo de impactos políticos.				
				0.63
9. Impacto sobre el grupo de investigación				
9.1 Se desarrollaron metodologías novedosas que pueden aplicarse en otros ámbitos.	3	2	1	2
9.2 Los resultados del proyecto contribuyen al prestigio personal y/o institucional.	3	3	2	2.7
9.3 El proyecto trajo consigo un aprendizaje que puede considerarse.	3	3	2	2.7
9.4 Favor de citar los diferentes resultados del proyecto y comentar su relevancia.				
				2.46

No-Nonsense Guide to Measuring Productivity

by W. BRUCE CHEW

A few years ago, a major manufacturing-based conglomerate asked a gifted mathematician to join its corporate staff. One of his first assignments was to design a system that senior managers could use to evaluate the operating efficiency of the company's various divisions. He devoted many months to the assignment and also tapped the knowledge of several academic experts. The result was a truly sophisticated model that combined historical performance data with economic forecasts to set target productivity levels for each business unit.

Much to management's dismay, however, when the results were in, the model suggested that not one unit was performing up to snuff. So headquarters asked the obvious question – Why? Why was an organization that was generating handsome profits and cash flows showing such disappointing productivity? The expert could not answer the question, nor was his model designed to do so. Not surprisingly, executives saw little value in the new system and scrapped it.

It's essential to measure productivity *appropriately*. Many companies that want to raise their competitiveness are investing a lor of money and faith in methods to track their plants' and offices' efficiency. Staff specialists or outside consultants – experts in cost accounting, statistics, and economics – usually play an important role in designing these systems. But specialists are often trained to focus on the technical elegance and statistical accuracy of productivity indexes. All too often, they introduce methods that are very precise but ignore the real challenges managers face.

While collecting information on productivity measurement systems and interviewing managers at plants across the United States during the last several years, I have seen many examples of effective productivity measurement – systems that have led to big strides in operating efficiency. But more frequently I have encountered frustration and confusion. A manager will look at a productivity index developed by a specialist and say, "Whoever came up with this has no idea what my business is like."

Productivity measurement is simply too important to be delegated to productivity specialists. But managers don't have to become experts themselves to ensure that existing systems meet their needs – or that new systems are relevant. A set of practical guidelines can help them understand, evaluate, and apply productivity measurement techniques effectively.

Look beyond direct labor

What is productivity? Remarkably, many people who make decisions every day about improving plant efficiency don't know how to answer this simple question. Let's begin with what productivity is *not*.

Productivity is not about wages. High wages can present a problem, not because workers are paid too much but because they produce too little. In deciding how best to measure productivity, managers should focus not on dollars per hour but on labor dollars per product. That is, on labor content, not labor cost. Workers who are very productive can be paid thousands of dollars more than employees elsewhere and the

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business can still prosper, as manufacturers like Lincoln Electric have demonstrated.

Productivity measurement should focus on overall capabilities, not on one set of costs. How good is your company at taking a pile of raw materials, a bunch of machines, stacks of paperwork, and groups of employees, and turning out useful goods or services? That's what a productivity index should address. It is, as much as possible, a relationship between physical inputs and outputs. The formula is disarmingly simple:

$$\text{Productivity} = \frac{\text{Units of output}}{\text{Units of inputs}}$$

The company producing more with a given set of inputs (capital, labor, and materials) or using fewer inputs to produce the same output has an advantage over the company producing less. Lower input costs create an added advantage – but not the principal advantage that productivity measures must identify. The central mission of a productivity index is to illuminate how a business can get more units of output per labor hour, per machine, or per pound of materials than its competitors.

Still, much of U.S. industry remains preoccupied with direct labor. At the national level, productivity figures *do* mean labor productivity. The Bureau of Labor Statistics, the primary source of productivity information, logically enough focuses on labor productivity. Cost accounting also reinforces this bias. The allocation of overhead, for example, is often based exclusively on labor hours. This approach may have been reasonable when labor hours represented a large percentage of total costs, but today, for many businesses, labor is a minor cost element. Or the bias may simply come from too many years when managing operations meant "kicking butts and taking names." If persuading people to work harder is all there is to efficiency, then stressing labor productivity makes sense.

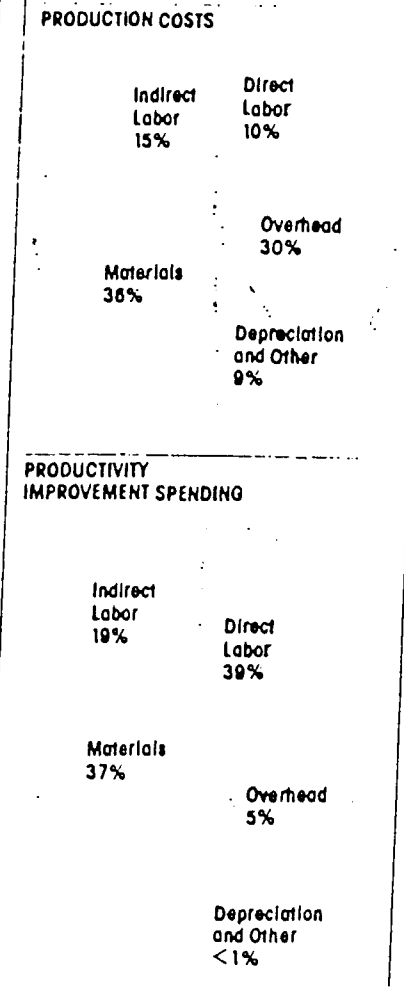
But there is much more to productivity, and many companies miss opportunities to bolster efficiency in nonlabor areas. Consider one U.S. plant manager's experience at a company with extensive fabrication and assembly operations. For a long time, he was uncomfortable with the way his division was allocating its annual $2 million productivity improvement budget. On being promoted to run all the division's plants, he at once reviewed spending on productivity programs. His intuition proved correct, as *Exhibit I* illustrates. Although direct labor accounted for only 10% of manufacturing costs, nearly 40% of the productivity budget was allocated to upgrading direct-labor efficiency. His subordinates are now looking for ways to reduce overhead and make better use of technology.

Single-minded attention to direct labor can produce unexpected consequences. Several years ago, a big New York bank concerned about labor costs in its back office implemented a department-by-department system to measure productivity, defined as transactions per employee. Senior management gave high visibility to the new system and even used it to calculate a large portion of the bonuses it paid to line managers. So the line managers computerized everything in sight. The result was increased productivity in every department but one – data processing. While staff was shrinking in the rest of the bank, data processing came under incredible pressure. It boosted its staff as well as its spending on hardware and software.

If that expansion in overhead was best for the bank, executives could never say for sure; their measurement system focused only on the productivity of direct labor. It didn't analyze the trade-offs between the productivity of departments (shorter turnaround times on letters of credit vs. growth in the data processing head count) or between cuts in variable costs (labor) and higher capital spending (new computers).

EXHIBIT I

How One Company Didn't Match Productivity Improvement Spending to Production Costs



Take a multifactor perspective

The trouble with single-factor productivity measures (whether output per labor hour, output per

Continued on page 114

machine, or output per ton of material) is that it is easy to increase the productivity of one factor by replacing it with another. Labor, capital, and materials are all potential substitutes for each other. Effective productivity measurement requires the development of an index that identifies the contribution of each factor of production and then tracks and combines them.

Take a hypothetical plant that machines purchased castings as one step in its production of motors. Now the company decides to purchase this component premachined. The premachined parts cost 20% more than standard castings, but buying them allows the company to lay off skilled workers and sell its machine tools. What happens to productivity? Output has remained constant, but the number of workers has fallen, so labor productivity is up. So too is capital productivity,

> A productivity index only helps if managers and workers understand the index.

by virtue of the lower asset base. But materials productivity has declined by 20% since output is unchanged, while the value of purchased materials has gone up.

In such a situation, a productivity index that focuses only on labor or capital would create strong incentives to reduce the value added by operations, which may not at all be management's goal. In theory, a company's make vs. buy decision process should prevent such unintended results. But with top management pushing hard for identifiable productivity increases, there is a real risk that defining productivity too narrowly will lead to unsound decisions by subordinates.

A multifactor view of productivity is important, therefore, but it is difficult for one index to encompass all inputs. Using several different single-factor measures can also yield a multifactor perspective. Indeed, even if a plant uses one aggregate measure, it still makes sense to use single-factor measures because they help identify the sources of aggregate productivity trends. A big change in a multifactor productivity measurement raises obvious questions: Is the change due to simultaneous shifts in the productivity of labor, capital, and materials, or has only one dimension changed?

Don't sacrifice function for form

A multifactor index to track productivity gives managers a convenient scorecard to answer the question, "How are we doing?" But an index can play this role only if managers and workers understand it, which may require certain compromises in mathematical elegance and accuracy. Economists and productivity specialists like to use sophisticated functional forms when they combine labor, materials, and capital into one index. Rather than simply adding everything up or averaging inputs, they prefer logarithmic and multiplicative techniques. When the chief goal is to study productivity behavior, as in statistical research, these approaches have theoretical advantages. But when the primary goal is to influence behavior, the simpler the better must be the rule. If the people who use an index can't understand it at a gut level, it probably will not affect their decisions and priorities.

Within Northern Telecom, some divisions make sure managers and workers understand multifactor productivity by including them in the design of department-specific indexes and by keeping the indexes simple. A department develops several performance ratios (no fewer than three, no more than seven) that it believes capture the essence of its mission. For example, one design engineering team proposes six ratios, among which are: reworked drawings as a percentage of total drawings, overdue drawings as a percentage of total drawings, and overtime hours as a percentage of total hours. Next the department identifies current performance, long-term goals, and interim goals for each ratio. Finally, managers assign weights to the ratios to reflect their relative importance, with the sum totaling 100. Thus the index produces a single productivity "score" (a weighted average of the ratios) that measures progress towards agreed-on goals in a way that everyone can understand.

This approach is not analytically perfect; there is no statistical reason to limit the number of ratios to seven, for example, and the weighting scheme is undeniably subjective. But Northern Telecom follows a basic principle that many other companies fail to appreciate: when deciding whether you need greater measurement precision, ask first whether greater precision will make a real difference in subsequent actions to improve productivity. Executives should seek the measure that promises the greatest impact, not the measure boasting the greatest accuracy or technical elegance.

The same principle applies to data collection. There are real costs associated with developing and implementing elaborate productivity systems. My research suggests that the point comes sometimes very early on where increased accuracy is not worth

additional cost. For example, the mismatch between the information provided by some accounting systems and what is needed for productivity analysis often means that bypassing the accounting data and developing data specifically for the productivity index will raise accuracy. But it is seldom worth the cost.

The costs can go even higher if you consider another factor: the time it takes to develop and implement a productivity measurement system. Lost time can translate directly into lost opportunities in today's turbulent business climate. As one manager complained to her staff, "Explain to me how taking an extra six months to get the measure more accurate is going to raise my productivity during those six months."

Measure the unmeasurable

It's a real challenge to develop a productivity index that captures the roles of the direct factors of production in a way that workers and managers can understand. But the challenge goes further. Conventional systems to measure productivity often overlook two aspects of the production process that are becoming very important in determining international competitiveness: production time and the role of employees other than shop-floor workers. Since neither lends itself well to direct measurement, productivity technicians often prefer to look the other way. Managers do so at their peril.

The first oversight, time, is not purchased, so it is usually ignored. But the production process certainly consumes time, and the fact that it is not purchased doesn't mean it's free. If two businesses use identical machines, the same number of people, and equivalent materials to produce identical products, most productivity indexes would produce identical scores. But suppose one business ships orders within three days of receiving them and the other takes three weeks. Is their productivity the same? Obviously not.

This is not an exaggerated example. Increasingly, companies are discovering the competitive power of shortening their production cycles—or the dangers of not doing so. But unless a productivity index assigns some value to the amount of time consumed, it is unrealistic to expect managers to focus on shortening turnaround times. Assigning inventory carrying costs is a step in the right direction, although most companies record carrying charges far below their true competitive costs. Carrying costs should not only be realistic but they should also reflect where the inventory sits (in terms of value added) as well as how long it sits. An additional time-based charge that captures how long it takes to complete an order can focus attention even more directly on possible gains in turnaround time.

The new head of a sheet metal plant owned by a major electronics company learned this lesson soon after he took over. His operation's primary role was to process prototypes of new products, but he discovered that several company divisions were routinely sourcing prototype work to outside suppliers because of his plant's unacceptably long lead times. Productivity measures of labor, capital, and materials were quite satisfactory; the plant's work flow had been structured to get the most out of its people and machines. But that represented a misunderstanding of its mission. So the new manager introduced a productivity index that focused on turnaround time, and he posted the results prominently. Eventually, the plant cut prototype production time from 20 weeks to three days. The reconfigured operation makes less "efficient" use of labor and materials, but can anyone argue that it is less productive?

The second crucial but often overlooked aspect of many productivity measurement systems regards whose performance is being measured. Most systems target inputs on the shop floor, but manufacturing efficiency is not only a function of who and what are located there. Engineers, supervisors, and other white-collar employees make significant contributions to manufacturing productivity, but few systems measure their roles. (The Northern Telecom system cited earlier is a notable exception.)

> Imperfect estimates of white-collar productivity are better than no estimates at all.

To a large extent, the absence of such measures reflects two principal difficulties of quantifying productivity in any service setting: measuring output and connecting employee actions to outputs. For the line worker in an auto plant, output is basically the number of cars or components produced. The connection between worker activity and output is also straightforward—the person tightens three bolts on every car, and this action helps complete the car. Measuring the productivity of product designers is a much more subtle problem. Defining output as simply the number of models or prototypes completed does not begin to capture these workers' true productivity. Designing an item to make

production smoother will improve the efficiency of the entire plant, for example. If such a design takes twice as long to complete as a simpler approach, it certainly does not mean that the engineer is less productive.

It isn't possible to measure white-collar outputs or inputs fully, but this fact doesn't mean that only blue-collar productivity can or should be measured. It does mean, however, that managers must be creative and open to new ways of thinking about an operation.

A plant manager of an important supplier to the auto industry met with resistance at headquarters to his request to augment his engineering staff. He knew that the additional money would be well spent, but he had no measurement system for making his case. The engineering staff focused heavily on improving the plant's use of materials. So aiming for a surrogate index, the manager argued that changes in the materials productivity index could be one indicator of the engineering team's productivity. Indeed, over time, as the size and expertise of the engineering group increased, the ratio of total output to materials input showed dramatic increases. As a result, the division's entire perspective on the relationship between the engineering function and manufacturing productivity changed.

Do surrogate measures give a complete picture of a group's performance? No. Are they true gauges of productivity? For the economist or measurement specialist, no. Can they focus managers and employees on critical aspects of the production process and, therefore, lead to improved performance? Yes. Productivity measures in the white-collar world can be relevant and effective, even if they aren't perfect.

Compare apples and apples

Ultimately, any productivity measurement system is only helpful if it's used appropriately. Management carries the burden of usage almost entirely. Productivity indexes today are being used to compare the performance of companies in an industry, plants in a company, and departments in a plant. The results influence investment choices, judgments about factory closings, and decisions on management compensation, so managers must be careful to make fair comparisons.

What is fair is not always obvious. Consider some of the ambiguities on the output side of the productivity ratio. *Exhibit II* describes the output in 1986 and 1987 of a hypothetical plant making two related products. In 1987, the price of product A rose, so many customers switched to product B. From the set of facts presented, what conclusions can be drawn about the change in output – and, therefore, the change in productivity? Depending on your point of view, output went up, down, or stayed the same. If you look at nominal revenues, output rose dramatically. If you adjust for the price change by comparing revenues using 1987 prices, output went down. If you focus on physical units, output stayed the same. You might look to standard costs for guidance, but they may also present a confusing picture as well as concerns about accuracy.

> If a company made one million 15,000-mile tires in 1986 and one million 30,000-mile tires in 1987, was output constant?

What really happened at the company depends on what really happened at the plant and in the marketplace, not in the numbers. Was product A radically redesigned? Was the old price relationship between the two products somehow incorrect? Was there a dramatic change in input costs for product A? A manager must consider questions like these before evaluating productivity trends in such a case.

Price changes, of course, are not the only important factor affecting output. Quality has an impact on productivity measures. The most productive plant or company does not necessarily have the

EXHIBIT II **What Is Output?**

The Facts

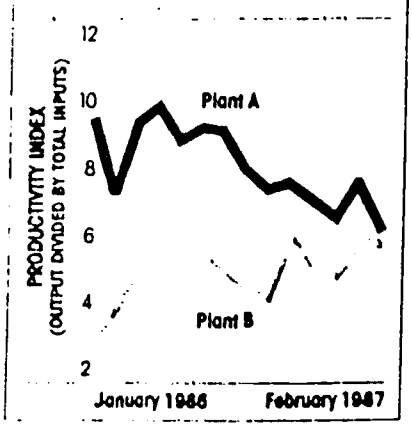
	1986		1987	
Product	*Units Produced*	*Price*	*Units Produced*	*Price*
A	2,000	$10	1,000	$25
B	2,000	$20	3,000	$20

Change In Total Output Equals

	1986	*1987*	*Percent Change*
In Units	4,000	4,000	0 %
Using Nominal Prices	$60,000	$85,000	+41.7%
Using 1986 Prices	$60,000	$70,000	+16.7%
Using 1987 Prices	$90,000	$85,000	− 5.6%

EXHIBIT III

Multifactor Productivity Trends at Two Plants



lowest cost per unit of output. It does have the lowest cost per *comparable* unit of output, though.

Suppose one company manufactures tires that last 15,000 miles and another company uses 10% more labor and materials to produce tires that last 30,000 miles. If the two businesses produce the same number of tires, it is not immediately clear which is more productive. Or suppose one enterprise, by virtue of a product development breakthrough, uses the same number of workers and machines to manufacture one million 15,000-mile tires in 1986 and one million 30,000-mile tires in 1987. Ignoring price for the moment, is output (and thus productivity) constant?

Comparing the performance of plants making different products requires a method to determine equivalencies. The three most common alternatives are standard costs, price, and technical parameters (like miles of tire life) that quantify product performance. No one focus is best; each has its strengths and weaknesses, and managers should select methods consistent with their company's strategy. If a company is and wants to remain a low-cost producer, it might focus on prices. If it wants to promote innovation, it might use technical parameters. Standard costs will focus attention on internal improvements independent of developments in the marketplace.

Managers also need to interpret trends, which can create further ambiguities. There is a fundamental distinction, for example, between levels of productivity and rates of productivity change. Looking at actual trends in a multifactor productivity index for two plants making identical products (*Exhibit III*), plant A's productivity exceeds plant B's in any given month and over the entire period. But whose performance should management worry about? As it turns out, plant B dramatically changed the run lengths in its production process, which improved productivity enormously. Corporate policies pushed plant A in the opposite direction, and its performance suffered. Here, focusing on absolute performance could mask important trends in relative performance.

Things are often not as they first appear with productivity data. One big manufacturer, after introducing a multifactor productivity index, discovered that its plants had suffered a significant productivity decline in the early 1980s. Bad management, right? Wrong. Demand for its product had fallen sharply during the period and, given the fixed inputs, overall productivity had declined. One plant had an especially large drop. Bad management, right? Wrong again. The plant, located in a rural area lacking skilled labor, treated skilled and semiskilled employees as fixed costs. To lay off these workers would be to lose them permanently to other employers. The large decline in productivity in response to a six-month downturn was thus evidence of good management; the employees should have been kept on. Productivity measurement raises issues and highlights changes, but it does not tell the whole story.

Proceed with care—but proceed

The complexities and ambiguities of productivity measurement should not discourage managers from using a system. Profit measures, after all, are also far from perfect, but we are accustomed to their shortcomings and have learned how to glean a wealth of insight from them. Managers should proceed with productivity measures, but with care. The seriousness of a system's shortcomings depends on how it is used; if bonuses or promotions are based on certain measures, they had better be accurate. But this degree of accuracy is unnecessary for most applications.

Perhaps the most important use of productivity measurement is as an objective source of information about long-term operating trends. An index can draw attention to plants or departments experiencing unusual problems or uncommonly strong performance. Productivity comparisons can also inspire useful exchanges of ideas. Differences in the amount of vertical integration or subcontracting, accounting policies, and many other factors often obscure the relative productivity of companies. Nonetheless, if a business finds itself a lot less productive than a competitor, it probably has a real problem. Managers may insist that the productivity gap is overstated, and they may be right. They will be hard-pressed, however, to argue that it does not exist.

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LIBROS DE INTERES SOBRE CREATIVIDAD

T I T U L O

CREATIVE THINKING AND BRAINSTORMING, por J. G. Rawlinson. Halsted Press, 1981

CREATIVITY, por S. W. Tiedt. General Learning Press, 1976.

CREATIVITY AND INNOVATION, por J. W. Haefele. Van Nostrand Reinhold, 1962.

CREATIVITY AND INNOVATION, por R. Mavor. Heriot-Watt Univ., 1969.

CREATIVITY AND INNOVATION, por H. Nystrom. Wiley, 1979.

CREATIVITY IN INDUSTRY, por P. R. Whitfield. Penguin, 1975.

HOW CREATIVE ARE YOU? por E. Raudsepp. Putnam, 1981.

LATERAL THINKING, por E. De Bono. Harper and Row, 1970.

THE MECHANISM OF MIND, por E. De Bono. Pelican Books, 1978.

OPPORTUNITIES; A HANDBOOK OF BUSINESS OPPORTUNITY SEARCH, por E. De Bono. Pelican Books, 1978.

LA REVOLUCION DE LA INTELIGENCIA, por L. A. Machado. Seix Barral, 1975.

UNDERSTANDING CREATIVITY; A LIGHTNING COURSE FOR EXECUTIVES, por J. N. Smith. Mantec Pubns., 1973.

información tecnológica y consultoría

CREATIVIDAD, INFORMACION Y CLIMA ORGANIZACIONAL

LA CREATIVIDAD, LA INFORMACION Y EL AMBIENTE ORGANIZACIONAL PARA PROYECTOS DE INNOVACION TECNOLOGICA

TEMARIO.

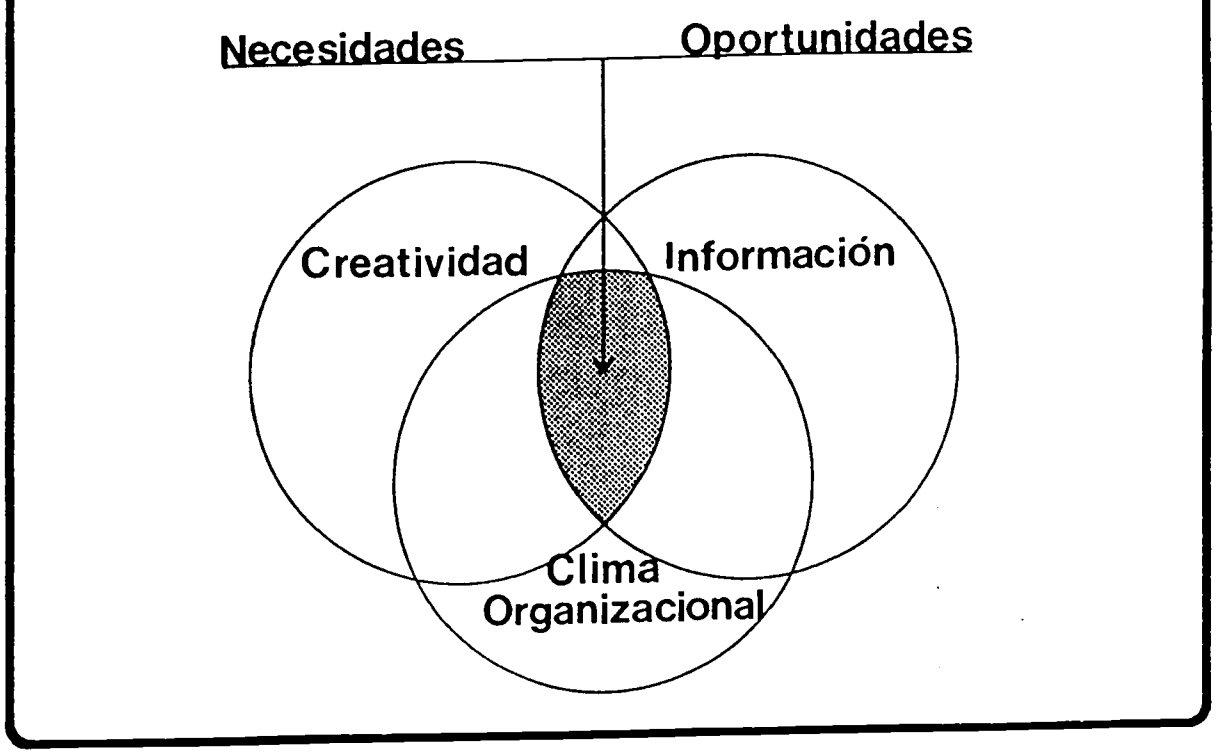
I. LA GESTACION DE UN PROYECTO
   A) DETECCION DE NECESIDADES Y OPORTUNIDADES
   B) GENERACION DE IDEAS
   C) IMPORTANCIA DE LA CREATIVIDAD EN EL DESARROLLO PROFESIONAL

II. DEFINICION DE CREATIVIDAD
   A) PREJUICIOS
   B) DESARROLLO DE LA CREATIVIDAD COMO DISCIPLINA
   C) ESCUELAS DE CREATIVIDAD
   D) EJERCICIO PRELIMINAR

III. EL CLIMA DE TRABAJO
   A) DEFINICION DE BARRERAS
   B) EJERCICIO DE ELIMINACION
   C) MOTIVACION

IV. LA INFORMACION
   A) ESPECIALIZACION VS. CREATIVIDAD
   B) EL MODELO DE LA MENTE
   C) PROCESO DE INCUBACION
   D) REFORZAR LA CREATIVIDAD

V. TECNICAS DE GENERACION DE IDEAS
   A) TECNICAS INDIVIDUALES
   B) TECNICAS DE GRUPO



LAS COMPAÑIAS HARAN CUALQUIER GASTO CON TAL DE MANTENER AL AYER VIVO Y VIGOROSO.

PETER DRUCKER

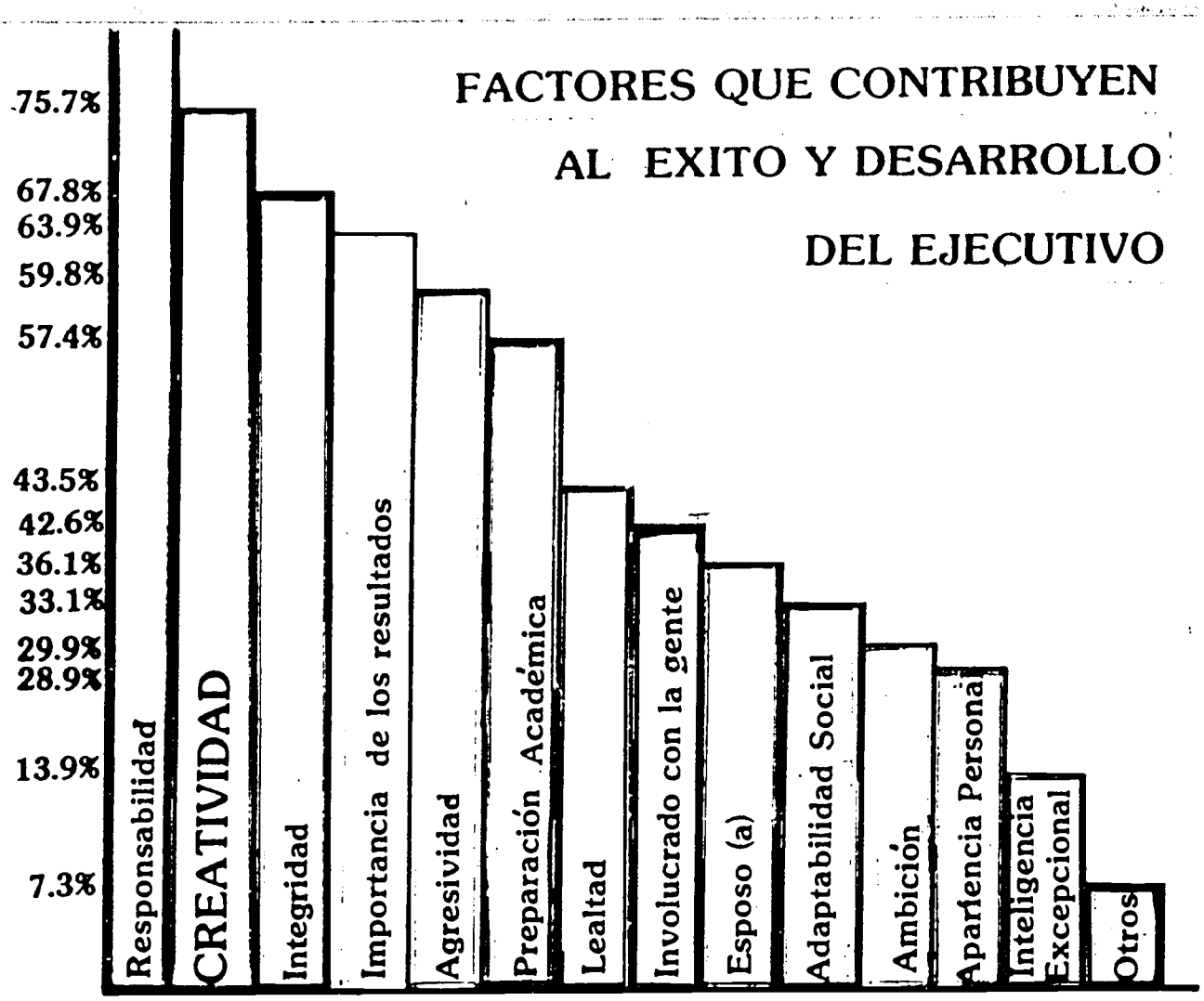


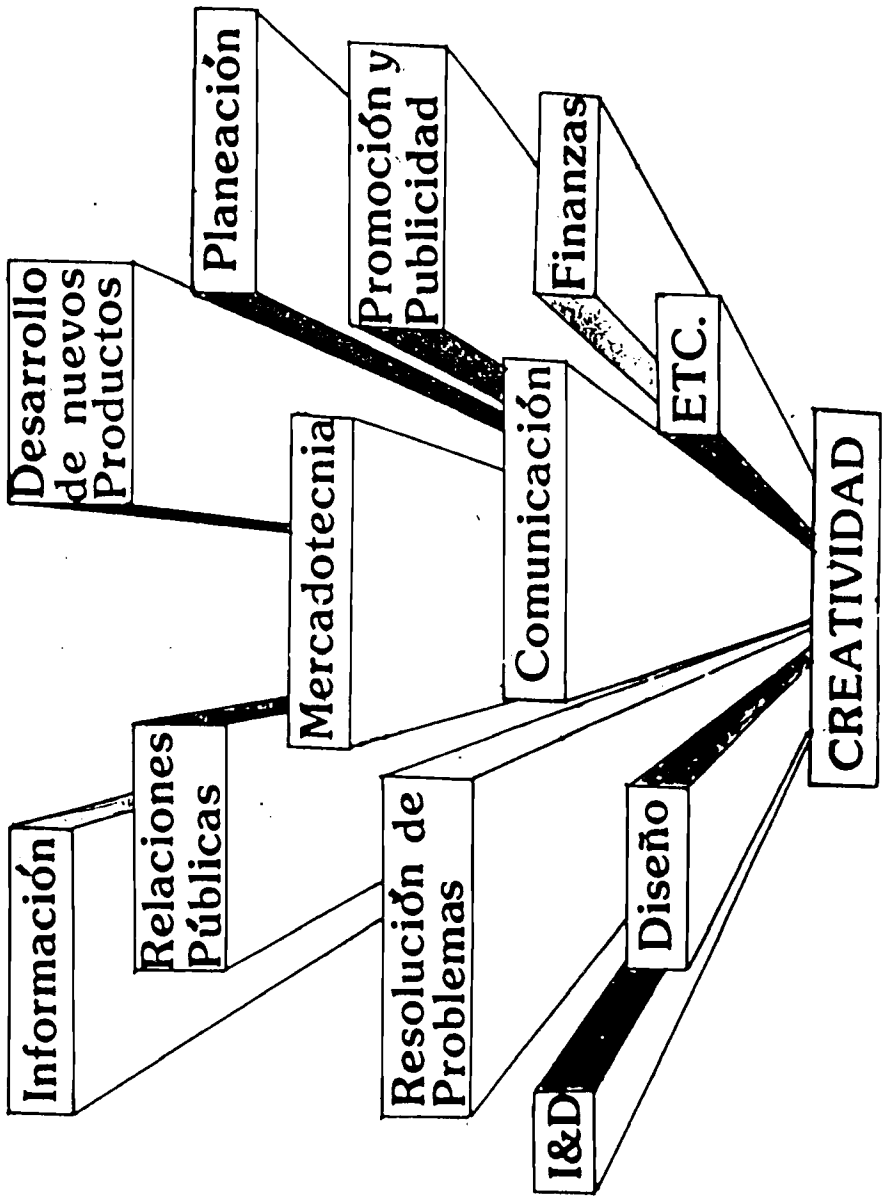
TABLA No. 40 FACTORES MÁS IMPORTANTES QUE CONTRIBUYEN AL DESARROLLO Y ÉXITO DEL EJECUTIVO

FACTORES	FRECUENCIA ABSOLUTA	FRECUENCIA RELATIVA (%)
CREATIVIDAD	815	75.7
RESPONSABILIDAD	919	85.4
INVOLUCRADO CON LA GENTE	458	42.6
IMPORTANCIA DE LOS RESULTADOS	741	63.9
AMBICIÓN	322	29.9
INTEGRIDAD	729	67.8
ADECUADA PREPARACIÓN ACADÉMICA	618	57.4
ESPOSA (O) APROPIADA (O)	388	36.1
LEALTAD	468	43.5
AGRESIVIDAD	643	59.8
APARIENCIA PERSONAL	311	28.9
ADAPTABILIDAD SOCIAL	356	33.1
INTELIGENCIA EXCEPCIONAL	150	13.9
OTROS	79	7.3

La creatividad es una parte tan básica del pensamiento, que aparece en todos los campos posibles: sistemas de información, comunicaciones, departamentos financieros, mercadotécnia, publicidad y promoción, relaciones laborales, investigación de operaciones, resolución de problemas, planeación, diseño, investigación y desarrollo, relaciones públicas, etc.

Es un error suponer - como muchos lo hacen - que la creatividad se emplea unicamente en desarrollo de nuevos productos.

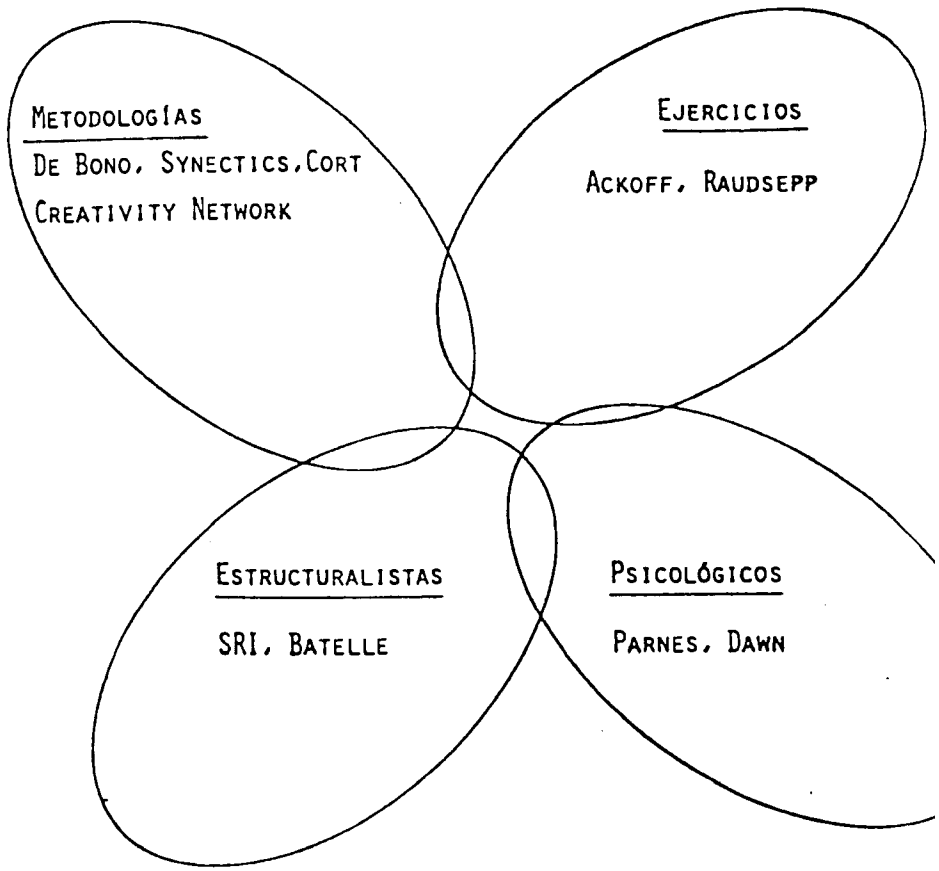
Edward De Bono

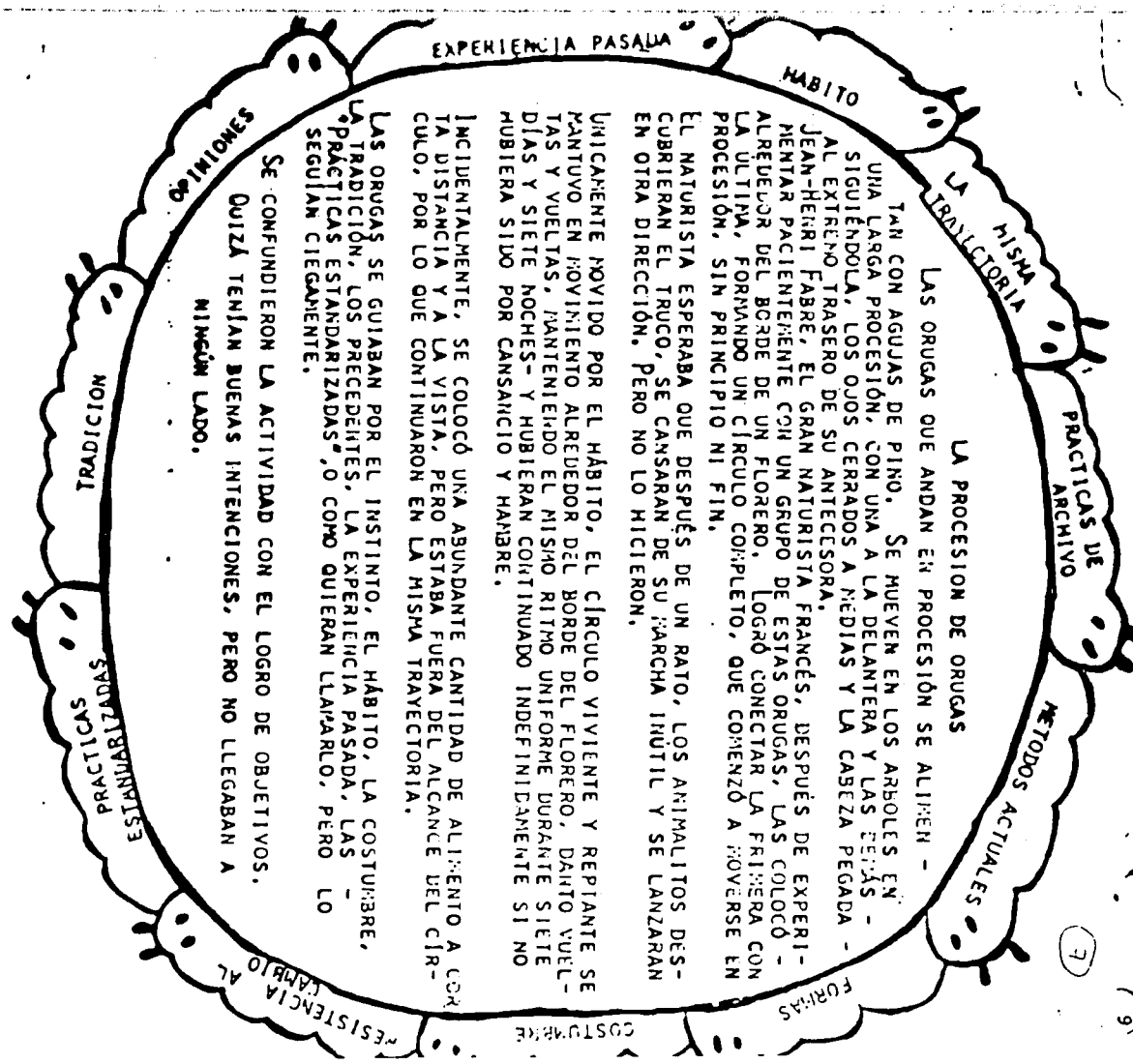


EL GENIO ES 1% DE INSPIRACION Y 99% DE TRANSPIRACION

THOMAS A. EDISON

ESCUELAS DE CREATIVIDAD

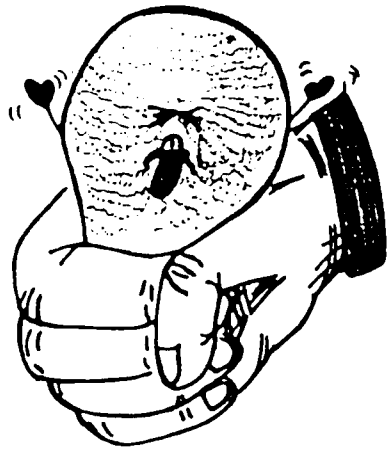




COMO MATAR LA CREATIVIDAD

Las doce reglas de oro de C. Taylor:

1. Presuponga que existe sólo un tipo de inteligencia o talento , sólo un tipo de habilidad.
2. Como profesor o supervisor ignore todo tipo de resultados científicos acerca de la creatividad.
3. Enseñe a los mejores y fusile a los demás
4. Siga haciendo aquello que hicieron a sus ideas y aun más.



5. Sea humano - reaccione rapidamente y en forma altamente negativa hacia nuevas ideas.
6. Si no lo entiende,! opongase a ello !

7. Siga al pie de la letra la regla: "Cuando más creativa sea una idea más se metera en problemas."

8. No haga uso de las oportunidades que se le presentan - lo cual es mejor que intentarlo y fracasar.

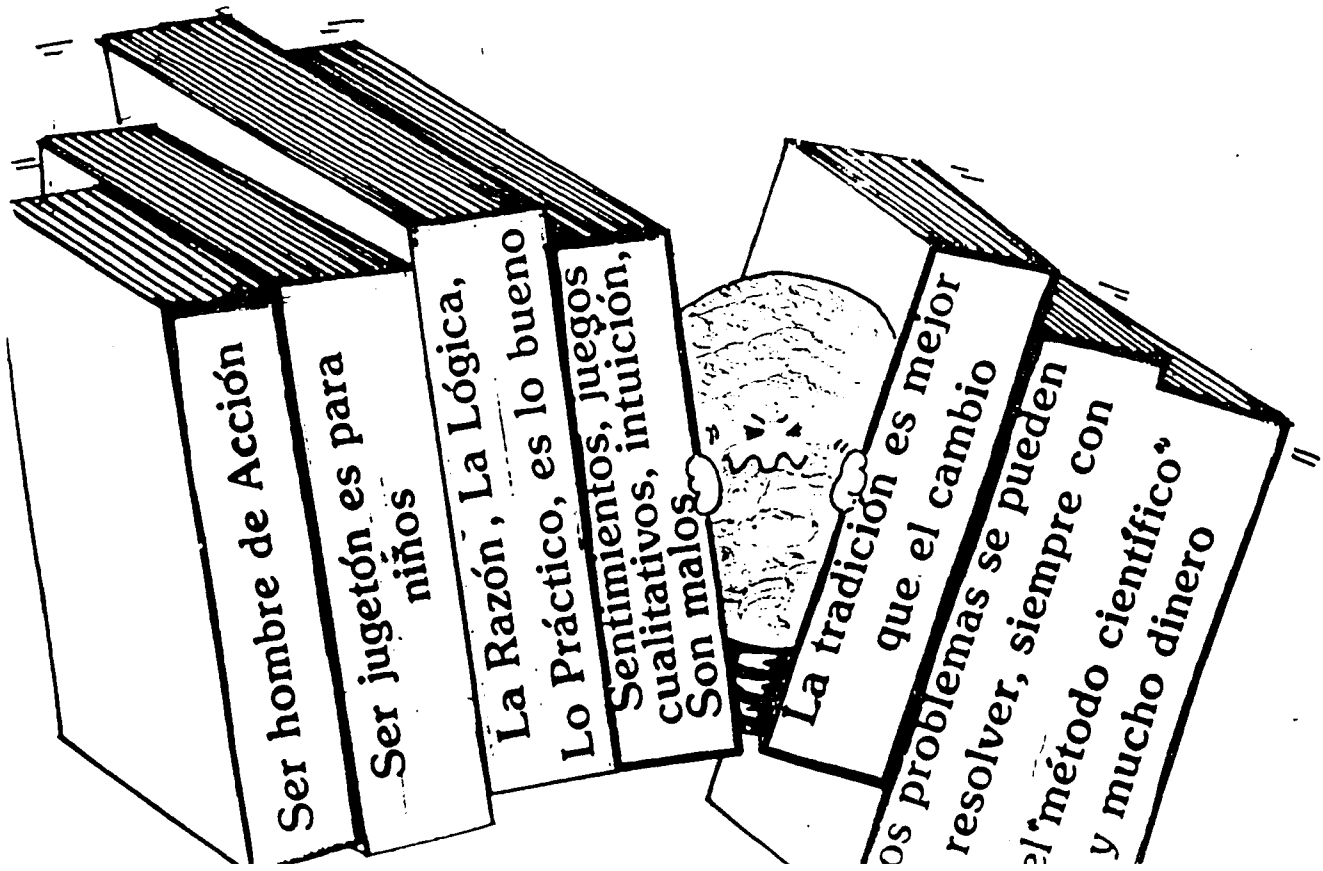
9. Organice a las personas creativas bajo su control o echelos fuera. Ostaculizandolos lo más que pueda.

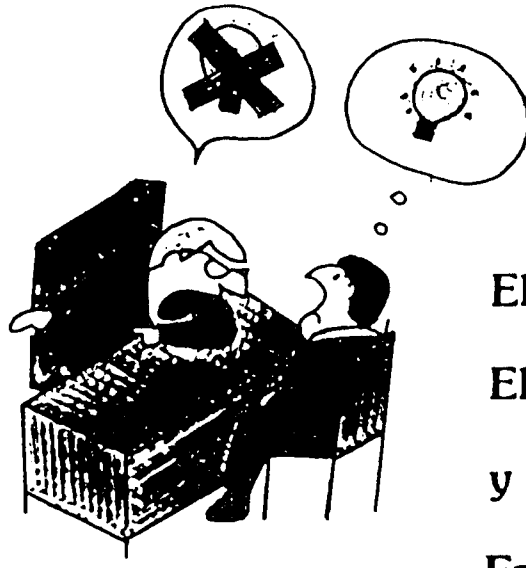
10. Diseñe e implante todo factor que inhiba o mate la creatividad en el salón de clases o en la organización en general.

11. Tenga un sistema mortalmente negativo para aquellas personas creativas y para las propias ideas creativas.

12. Guarde celosamente todas las prerrogativas solo para usted que sea el único que planea piensa y crea en su organización.

BARRERAS CULTURALES





BARRERAS AMBIENTALES

El Jefe autocrático

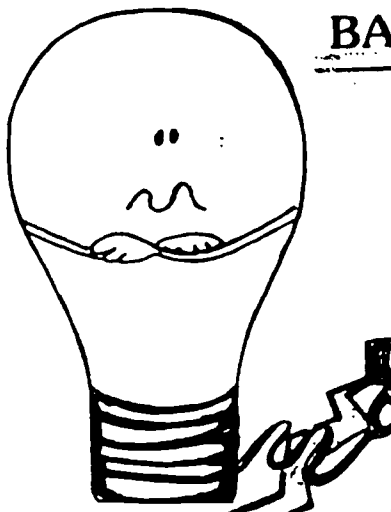
El ambiente de poca cooperación y confianza

Falta de Tiempo

No hay apoyo a las ideas

Distracciones

BARRERAS INTELECTUALES



Falta de Información

Exceso de Especialización

Inflexibilidad en las Estrategias Intelectuales

C R E A T I V I D A D

BARRERAS

BARRERAS DE PERCEPCION

DEFINIR, ESTRUCTURAR
VER PUNTOS DE VISTA DIFERENTES
LIMITARSE ARTIFICIALMENTE
JUZGAR PREMATURAMENTE
SATURARSE

BARRERAS EMOCIONALES

ENAMORARSE DE LAS IDEAS PROPIAS
DESINTERÉS - NO HAY RETO
EXCESO DE MOTIVACIÓN
MIEDO AL FRACASO
INCAPACIDAD DE TOLERAR LA AMBIGUEDAD
INCAPACIDAD DE AFLOJAR LA TENSIÓN
ARROGANCIA.

12

BARRERAS CULTURALES

SER " HOMBRE DE ACCIÓN "
SER JUGUETON ES PARA NIÑOS
LA RAZÓN, LA LÓGICA, LO PRÁCTICO, ES LO BUENO.
SENTIMIENTOS, JUICIOS CUALITATIVOS, INTUICIÓN, SON MALOS.
LA TRADICIÓN ES MEJOR QUE EL CAMBIO.
LOS PROBLEMAS SIEMPRE SE PUEDEN RESOLVER - CON EL MÉTODO CIENTÍFICO Y MUCHO DINERO.

BARRERAS DE IMAGINACION

TEMOR AL INCONSCIENTE
SUPRIMIR LA IMAGINACIÓN -ES PERDER EL TIEMPO

BARRERAS DE COMUNICACION

DIFICULTAD PARA EXPRESAR LAS IDEAS
LENTITUD EN LA EXPRESIÓN

¿ POR QUE UN MODELO DE LA MENTE ?

A LA PERSONA INTERESADA EN APRENDER TÉCNICAS DE CREATIVIDAD PARA LA INNOVACIÓN TECNOLÓGICA Y LA BÚSQUEDA DE OPORTUNIDADES DE NEGOCIOS, LE PARECERÁ EXTRAÑO EL QUE SE LE PROPONGA ESTUDIAR UN MODELO DEL MECANISMO DE LA MENTE.

SIN EMBARGO, SE INCLUYE ESTE MODELO EN EL PRESENTE CURSO DEBIDO A QU ES UNA DE LAS MÁS PODEROSAS ARMAS DE QUE SE DISPONE PARA DESARROLLAR LA CREATIVIDAD.

EL CONOCIMIENTO DE ESTE MODELO PERMITE DESCUBRIR MUCHAS DE LAS BARRE RAS A LA CREATIVIDAD QUE TODOS POSEEMOS, Y LO QUE ES MÁS IMPORTANTE LA MANERA DE EVITARLAS.

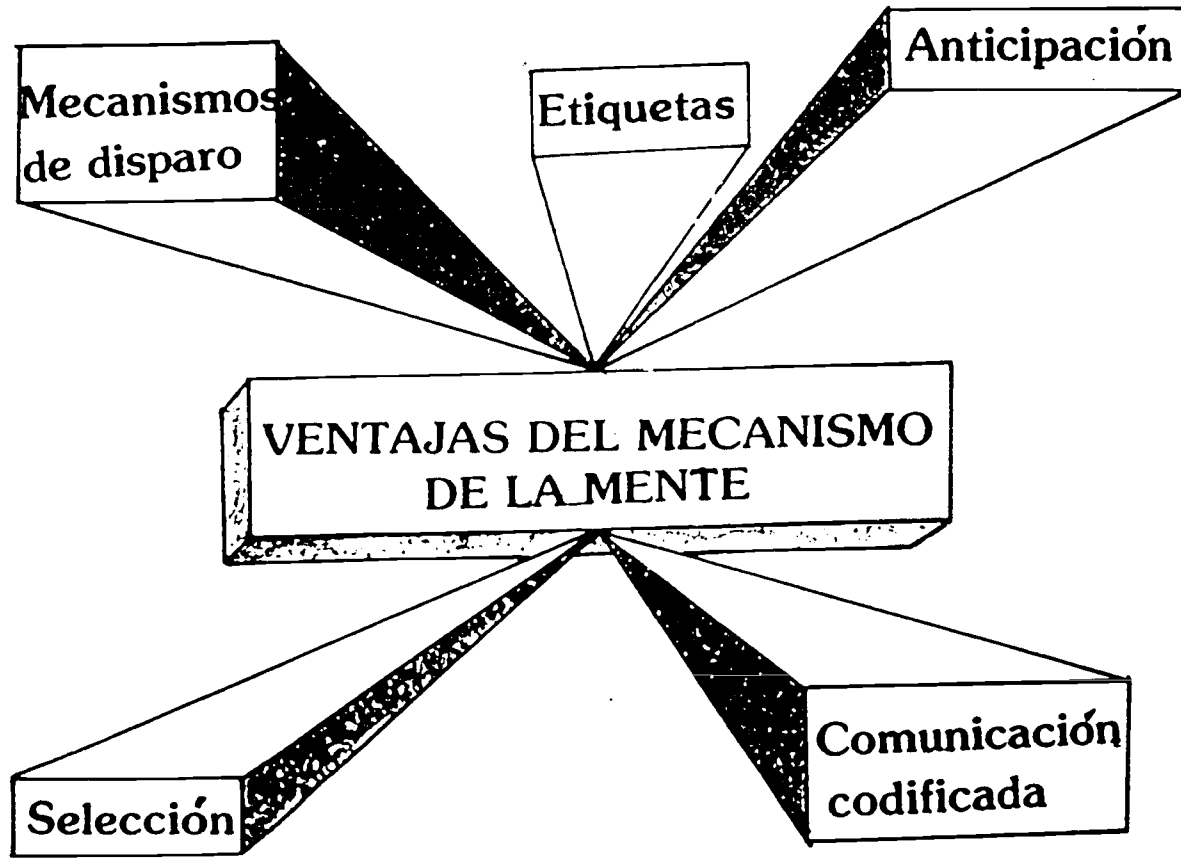
POR OTRA PARTE, ES UN INSTRUMENTO QUE DA LÓGICA Y CONGRUENCIA A LAS TÉCNICAS DE CREATIVIDAD QUE AQUÍ SE EXPONEN, Y QUE PERMITE JUZGAR S EFECTIVAMENTE SON EFICACES PARA DESARROLLARLA. QUIÉN DOMINE ESTE MO LO A FONDO, NO SOLO ESTARÁ CAPACITADO PARA ENTENDER Y EVALUAR LAS T NICAS QUE SE LE OFREZCAN, SINO INCLUSO PODRÁ DESARROLLAR TÉCNICAS N VAS O VARIANTES APROPIADAS A CADA SITUACIÓN.

ESTE MODELO HA SIDO ELABORADO POR EL DR. EDWARD DE BONO Y SE ENCUEN TRA UNA EXPLICACIÓN DETALLADA EN SU LIBRO :" THE MECHANISM OF MIND

SUPERFICIE DE MEMORIA

COMPUTADORA	MENTE HUMANA
Registra todos los datos	Registra de acuerdo a "Preferencias"
No tiene preferencias	
Cada dato tiene igual valor, no importa cuantas veces se repita	Los datos repetidos se aceptan con mas facilidad
La memoria recibe cada dato imparcial y objetivamente	La memoria se organiza a sí misma y tiene un proceso maximizante
El orden de entrada de los datos no tiene importancia	El orden de entrada de los datos tiene la mayor importancia
Cada dato es procesado en funcion de sí mismo	Cada dato es procesado en función de los datos ya almacenados
El registro es permanente	Hay una memoria de corto plazo y una de largo plazo
Puede distinguir facilmente entre patrones de datos muy parecidos	Asimila los patrones de datos muy similares en uno solo, que es el primero que se estableció

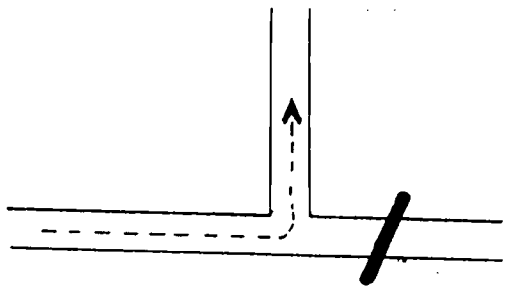
42

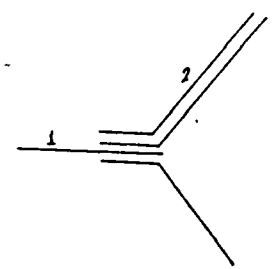


Dificultades de la mente:

Falta de selección
Falta de ajuste fino
Bloqueo para las aperturas
Cortar a través de patrones
Dificultad del cambio de patrón
Polarización
Los patrones crecen cada vez más
Los patrones crecen por extensión
Suposiciones
Los patrones pierden significado
Errores
Importancia de la secuencia de adquisición de datos
Continuidad

PRIMERA ETAPA	SEGUNDA ETAPA
PERCEPCION	PROCESO
Conceptualización Definición Determinar: Factores Características Efectos Valores	Lógica Matemática Análisis Síntesis Inducción Deducción

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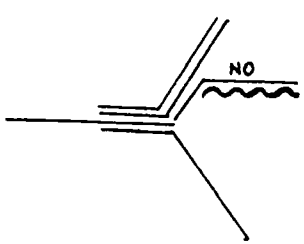
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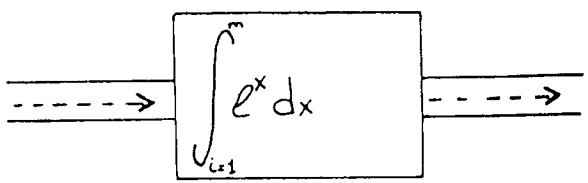
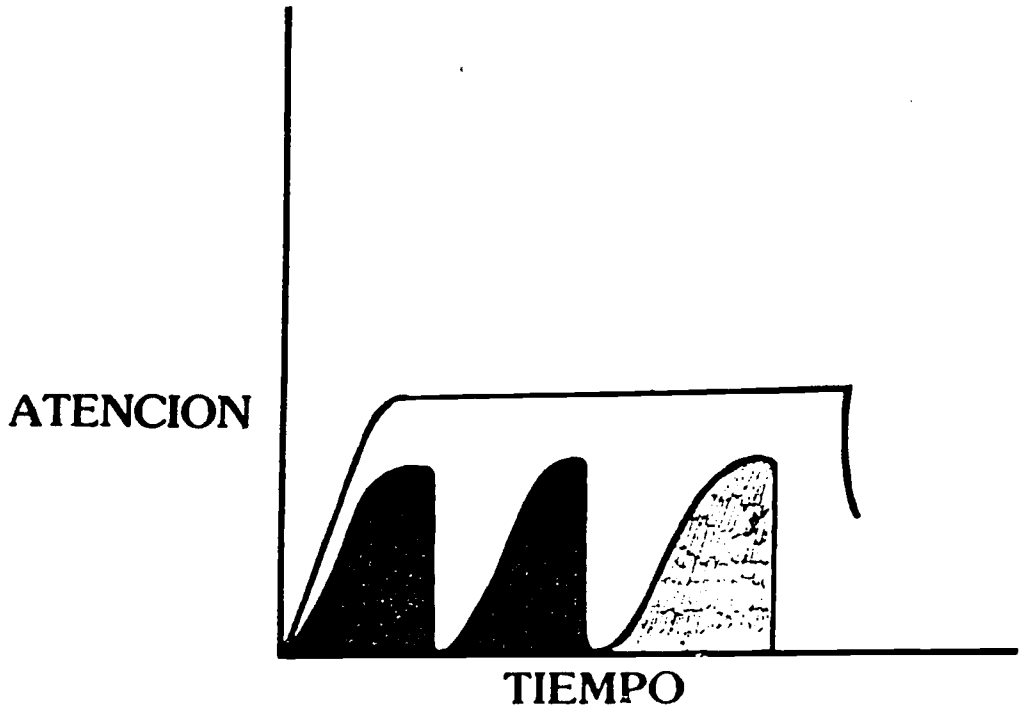

$\int_{i=1}^{m} e^x dx$

ESTRATEGIAS PARA LA PRIMERA ETAPA:

1. Esperar.
2. Exponerse a mayor información.
3. "Fusilar"
4. Organizar la información.
5. Procesar la información
6. Aclarar la información

INCUBACION

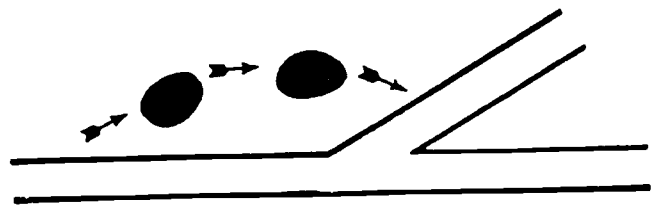


·57·A

SUSPENDER EL JUICIO

- En cuanto a lo relevante de la información.
- En cuanto a la a la validez de mi propia idea.
- En cuanto a la validéz de la idea de alguien más.
- Juzgar la validez de la idea antes de ofrecerla a otros.

Lo importante es el valor de la idea para generar movimiento.



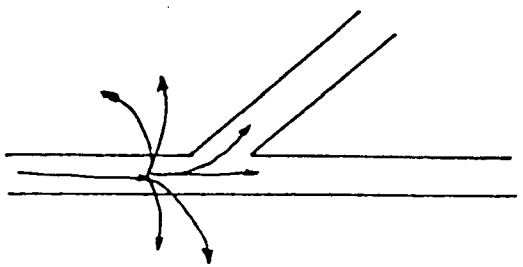
GENERACION DE ALTERNATIVAS.

- MODOS DE DEFINIR EL PROBLEMA
- MODOS DE ENFOCAR EL PROBLEMA.

TECNICAS:

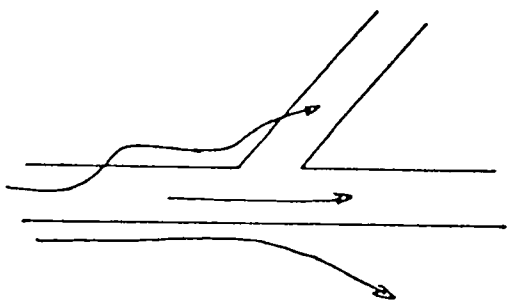
CUOTA

REDEFINICION



CUESTIONAR LO ESTABLECIDO.

- CUESTIONAR LA NECESIDAD DE LIMITES.
- CUESTIONAR LA VALIDEZ DE LOS CONCEPTOS.



CUESTIONAR LO ESTABLECIDO

PREGUNTAS PROVOCATIVAS

¿ POR QUÉ ?

¿ PARA QUÉ ?

¿ Y SI NO, ... QUÉ ?

¿ TIENE QUE SER ASÍ ?

¿ ES EL ÚNICO MODO DE HACERLO ?

¿ SE TIENE QUE SEGUIR HACIENDO ASÍ ?

¿ POR QUÉ LO HACEMOS DE ESTE MODO ?

SIEMPRE SE HA HECHO ASÍ

ESTE MODO ES TAN BUENO COMO CUALQUIER OTRO

HAY OTROS MEDIOS MEJORES, PERO EL CAMBIO ES COSTOSO

NO SE PUEDE CAMBIAR

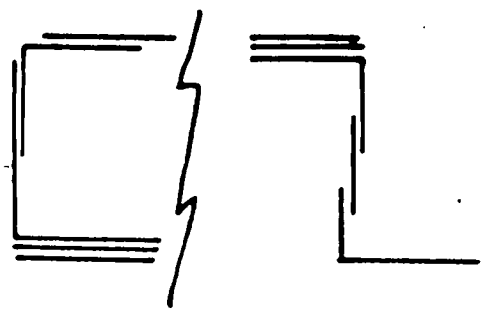
NO HAY BENEFICIOS EN CAMBIAR

FRACCIONAR.

DIFERENTE DE ANALIZAR EN LOS COMPONENTES.

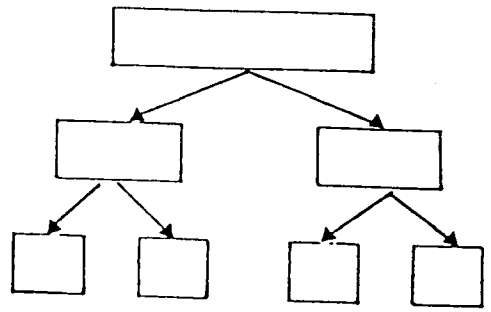
LA MIRA ESTA EN REESTRUCTURAR, NO EN ANALIZAR.

SE BUSCA ESCAPAR DE LA UNIDAD DE UN PATRON.

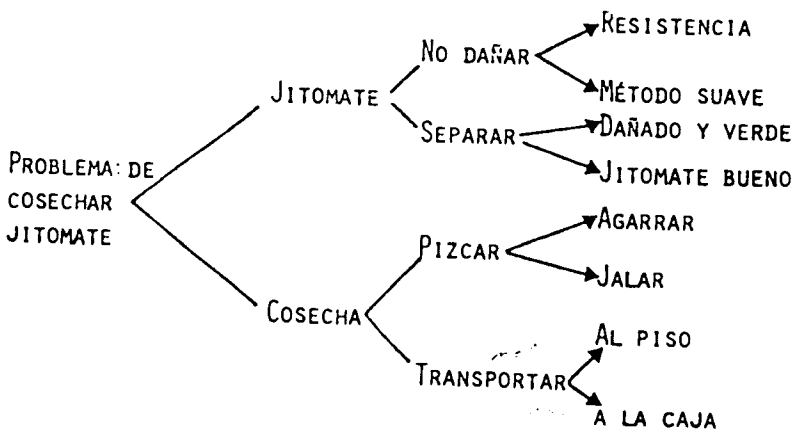


FRACCIONAR

DIVISION EN DOS UNIDADES

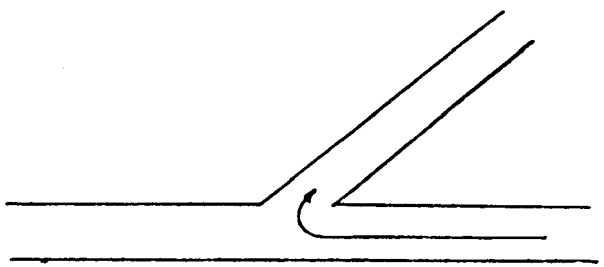


EJEMPLO: MÁQUINA PARA COSECHAR JITOMATE



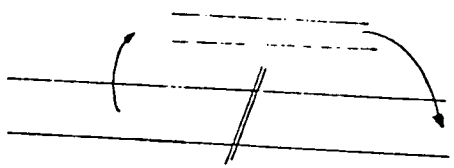
EL METODO DE LA REVERSA.

- SE USA PARA ESCAPAR DE LA NECESIDAD DE VER LAS COSAS MODO NORMAL.
- EL PROPOSITO PRINCIPAL ES PROVOCATIVO.



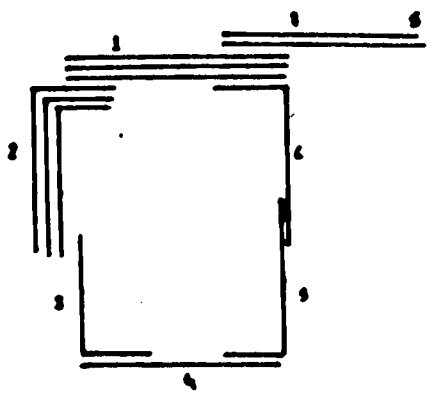
A N A L O G I A S.

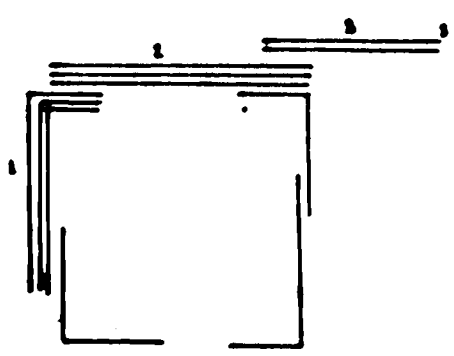
SE RELACIONA EL PROBLEMA A UNA ANALOGIA Y DESPUES DE DESARROLLA LA ANALOGIA SOBRE SUS PROPIAS LINEAS DE DESARROLLO. LA ANALOGIA NO TIENE QUE AJUSTARSE DEL TODO.



SELECCION DEL PUNTO DE ENTRADA.

- **CAMBIAR EL ORDEN DE LA SECUENCIA DEL PENSAMIENTO.**
- **INICIAR POR EL FINAL.**
- **ROTACION DE LA ATENCION.**





PREGUNTAS DE OSBORN

PARA GENERAR IDEAS

¿ OTRAS APLICACIONES ? (¿NUEVAS FORMAS DE UTILIZARLO ? ¿ OTROS USOS SI SE MODIFICA ?)

¿ ADAPTAR ? (¿ QUÉ OTRA COSA ES COMO ÉSTA ? ¿ QUE OTRAS IDEAS SUGIERE ? ¿ HAY ALGO PARALELO EN EL PASADO ? ¿ QUE SE PUEDE COPIAR ? ¿ A QUIEN SE PUEDE EMULAR ?)

¿ MODIFICAR ? (¿ NUEVO GIRO ? ¿ CAMBIO DE SIGNIFICADO, COLOR, MOVIMIENTO, SONIDO, OLOR, GUSTO, FORMA ? ¿ OTROS CAMBIOS ?)

¿ AGRANDAR ? (¿ QUÉ SE PUEDE AGREGAR ? ¿ MÁS TIEMPO ? ¿ MAYOR FRECUENCIA? ¿ MÁS FUERTE ? ¿ MÁS ALTO ? ¿ MÁS LARGO ¿ MÁS GRUESO ? ¿ MÁS PESADO ? ¿ VALOR ADICIONAL ? ¿ MÁS INGREDIENTES ? ¿ DUPLICAR ? ¿ MULTIPLICAR ? ¿ EXAGERAR ?)

¿ REDUCIR ? (¿ QUE SE LE PUEDE QUITAR ? ¿ MÁS PEQUEÑO ? ¿ CONDE SADO? ¿ EN MINIATURA ? ¿ MÁS BAJO ? ¿ MÁS CORTO ? ¿ MÁS DELGADO ? ¿ MÁS LIGERO ? ¿OMITIR ? ¿ MÁS LEN TO? ¿ MÁS RECTO ? ¿ SEPARADO EN DOS ? ¿ SUBDIVIDI DO ? ¿ MENOS FRECUENTE ?)

¿ SUBSTITUIR ? (QUIÉN EN SU LUGAR ? ¿ QUÉ EN SU LUGAR ? ¿ OTRO INGREDIENTE ? ¿ OTRO MATERIAL ? ¿ OTROS PROCESOS ? ¿ OTRA POTENCIA ? ¿ OTRO PLANO ? ¿ OTRO MECANISMO ¿ OTRO TONO DE VOZ ? ¿ OTRO TIEMPO ?)

¿ REDISPONER ? (¿ INTERCAMBIAR COMPONENTES ? ¿ OTRO PATRÓN ? ¿ OT DISPOSICIÓN ? ¿ OTRA SECUENCIA ? ¿ CAMBIO DE CALEN DARIO ? ¿ MÁS TEMPRANO ? ¿ MÁS TARDE ? ¿ INTERCAMBIAR CAUSA Y EFECTO ? ¿ CAMBIAR DE RITMO ?)

¿ INVERTIR ? (¿ INTERCAMBIAR POSITIVO Y NEGATIVO ? ¿ CONSIDERAR L OPUESTOS ? ¿ DARLE VUELTA ? ¿ PONERLO DE ATRÁS PAR

ADELANTE ? ¿ DE ARRIBA PARA ABAJO ? ¿ DE ADENTRO HACIA FUERA ? ¿ INVERTIR PAPELES ? ¿ CAMBIAR ZAPATOS ? ¿ GIRAR LAS MESAS? ¿PONER LA OTRA MEJILLA ?

¿ COMBINAR ? (¿ UNA MEZCLA ? ¿ UNA ALEACIÓN ? ¿ UNA COMBINACION DE ELEMENTOS SURTIDOS ? ¿ UN CONJUNTO ? ¿ UNA COMBINACION DE UNIDADES ? ¿ COMBINACIÓN DE PROPÓSITOS ? ¿ COMBINACIÓN DE ATRACTIVOS ? ¿ COMBINACION DE IDEAS ?)

ESTIMULO AL AZAR.

EXPOSICION:

A IDEAS DE OTROS

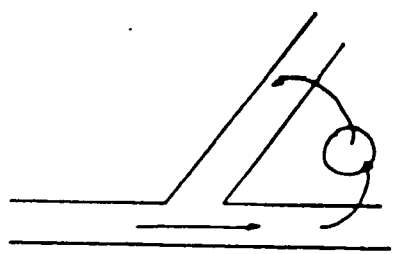
A IDEAS Y METODOS DE CAMPOS DISTINTOS

PONER ATENCION A LO QUE NO ES RELEVANTE.

GENERACION FORMAL DE ESTIMULOS.

PALABRAS AL AZAR

OBJETOS AL AZAR.



TORMENTA DE IDEAS Y SUS VARIACIONES.

- DISCUSION SIN RESTRICCIONES.
- NO SE PERMITEN CRITICAS.
- ENFASIS EN LA CANTIDAD DE IDEAS.
- SE ALIENTAN LAS IDEAS FANTASIOSAS, HUMORISTICAS Y LAS ASOCIACIONES ESPONTANEAS.

TORMENTA DE IDEAS
TECNICA PARA OBTENER IDEAS Y RESOLVER PROBLEMAS

A CONTINUACION DESCRIBIMOS LOS PASOS DE UN PROCEDIMIENTO PARA RESO PROBLEMAS CONOCIDO COMO " TORMENTA DE CEREBROS" O "TORMENTA DE IDEA GRAN PARTE DEL ÉXITO DE ESTE PROCEDIMIENTO RESIDE EN SEGUIR UNAS PO Y SENCILLAS REGLAS; NO SÓLO ES EL LÍDER QUIEN DEBE ESTAR MUY BIEN F LIARIZADO CON ESTAS REGLAS, SINO QUE EL GRUPO TAMBIÉN DEBE ESTAR CO CIENTE DE ELLAS Y DISPUESTO A OBSERVARLAS.

I. EL GRUPO NO DEBE EXCEDER DE 10 PERSONAS NI TENER MENOS DE 5 MIEM

II. TODOS LOS MIEMBROS DEL GRUPO DEBEN TENER ALGUNA INFORMACIÓN PRE EXPERIENCIA CON EL PROBLEMA.
   A. IDEALMENTE, ESTO DEBE VARIAR DESDE UN PAR DE "EXPERTOS" EN EL MA HASTA ALGUNOS INDIVIDUOS QUE SÓLO CONOCEN EL ÁREA POR REFE CIAS.

III. DEBE DESIGNARSE A UN MIEMBRO DEL GRUPO COMO EL LÍDER, Y A OTRO BRO COMO REGISTRADOR.
   A. EL REGISTRADOR ANOTA TODAS LAS IDEAS, AÚN LAS QUE APARENTEME SE SOBREPONEN, SOBRE UN PIZARRÓN O UN PLIEGO DE PAPEL COLOCA DELANTE DEL GRUPO. TAMBIÉN PUEDE APORTAR SUS PROPIAS IDEAS.
   B. EL LÍDER ES EL FACTOR CRUCIAL DE TODO EL PROCEDIMIENTO.
      1. DEBE CONTAR CON EL RESPETO DEL GRUPO; NO NECESARIAMENTE D SER UN EXPERTO EN ESE PROBLEMA EN PARTICULAR, PERO DEBE S ACEPTADO COMO LÍDER.
      2. DEBE TENER LAS CUALIDADES DE UN BUEN MODERADOR.

IV: EL TIEMPO ASIGNADO A LA SESIÓN DE TORMENTA DE IDEAS DEBE SER VAR BLE. EL PERÍODO QUE PUEDE RESULTAR PROVECHOSO VARIARÁ MUCHO CON L NATURALEZA DEL PROBLEMA Y LAS CARACTERÍSTICAS DEL GRUPO EN SI. A OJO DE BUEN CUBERO, UNA HORA SERÍA EL TIEMPO MÍNIMO Y DOS HORAS E MÁXIMO.

V. EL PROCEDIMIENTO A SEGUIR EN LAS SESIONES ES LA SIGUIENTE:

A. Calentamiento por parte del líder - bromas, chistes, comentarios, anécdotas, ejercicios o problemas breves para atraer la atención y el interés del grupo.

B. Definición preliminar del problema, en términos que conduzcan a - un pensamiento creativo, pero suficientemente específicos como -- para evitar irse por las ramas.

C. Explicación de las reglas que deben observarse en la sesión, (el líder las explica, y son las siguientes:)
   1. Todas las ideas se van a registrar a la vista del grupo
   2. Se requiere una abundante cantidad de ideas
   3. El grupo debe dejar de lado el sentido crítico y aportar ideas aunque parezcan tontas o ridículas.
   4. La crítica, el ridículo o la evaluación se harán a un lado, no se aceptarán en ninguna forma durante la sesión. No se admitirán frases como " Ya lo intentamos antes ", " No es práctico," " Bueno, quizá funcione", " Lo veo dudoso ", "Es un locura" , etc.

D. El líder deberá :
   1. Comenzar la sesión aportando una idea propia, cuanto más osada, mejor.
   2. Cuando comiencen a surgir las ideas del grupo, estimularlo :
      A. Aportando ideas complementarias
      B. Elaborando la idea de uno de los miembros
      C. Haciendo uso formal de una de las listas de verificación
      D. Pidiendo un receso si todo lo demas falla.
   3. A veces es conveniente establecer una meta original; por ejemlo, " Debemos apuntar 40 ideas "
   4. Intervenir inmediatamente si aparece alguna forma de crítica o de ridiculización.
   5. Hacer que el grupo regrese al problema si es que se han alejado de él.
   6. Subrayar que las modificaciones o mejoras sobre las ideas aportadas no sólo son aceptables, sino también muy apreciables.
   7. Cuidar que - como en cualquier junta - no haya unos pocos individuos que monopolicen la sesión.

VI. Si es posible, reunir el mismo grupo un poco después para evaluar las ideas. Durante este interín, el registrador u otras personas pueden revisar la lista de ideas agrupando las similares en categorías y - eliminando las repeticiones. Se deben preparar listas impresas de - estas ideas para cada uno de los miembros del grupo.

ASESINOS DE IDEAS

LOS SIGUIENTES SON EJEMPLOS DE " ASESINOS DE IDEAS ".¿QUÉ FRASES SIMILARES HAY EN LA DIVISION DE PRODUCCION QUE ASESINAN IDEAS ?

1. " HICIMOS ÉSTO ANTES Y NO RESULTÓ "
2. " ÉSTO ES BUENO PERO VAMOS A HACERLO MEJOR " (UNA GRAN CANTIDAD DE TRABAJO EXTRA ES OFRECIDO, A QUITARLE LA IDEA)
3. " ÉSO ESTA PROGRAMADO PARA EL AÑO QUE VIENE "
4. " ¿ CUÁNTO AHORRAREMOS ? "
5. " ÉSO PUEDE TRAER SERIAS IMPLICACIONES, ES PELIGROSO "
6. " SIGUE ADELANTE TÚ, ESO ES COSA TUYA "
7. " NO ALBOROTES ESE AVISPERO DE NUEVO "
8. " LA INDIFERENCIA, BOSTEZOS "
9. " ! VAYA IDEAS ! (REALMENTE ESTIMULA A LA GENTE A HACER LO CONTRARIO)
10. " ! BAH ! "
11. " VAMOS A PASARLE ESTO A UN GRUPO DE CONSULTA " EQUIPO DE TRABAJO
12. " MUECAS "
13. " NO TENEMOS PERSONAL DISPONIBLE "
14. " DEJEMOS ESTO A GOBIERNO "
15. " ÉSTO NO ES POSIBLE "
16. " ESA SOLUCIÓN ES MUY COSTOSA Y NO HA SIDO PRESUPUESTADA "
17. " ESO NO FUNCIONA "
18. " MUY BIEN PERO MÁNDAME UNA NOTA "
19. " DÉJAME PENSARLO, LUEGO LO DISCUTIMOS "
20. " ÉSO ESTÁ MUY BIEN, PERO PRIMERO TENEMOS QUE RESOLVER OTROS PROBLEMAS "
21. " YA TENEMOS SUFICIENTES PROBLEMAS "
22. " YA HAY UNA COMISIÓN ESTUDIANDO ESE PROBLEMA "
23. " MI EXPERIENCIA DE TRABAJO ES MÁS PRÁCTICA QUE TUS IDEAS "
24. " LO HACEMOS DE ESTA MANERA PORQUE LAS NORMAS SON ASÍ "
25. " ÉSO ES RESPONSABILIDAD DE CARACAS "
26. " ESTAMOS AQUÍ PARA PRODUCIR PETRÓLEO, VALE "
27. " HAY MUCHO TRABAJO, CHICO "
28. " ES TECNICAMENTE FACTIBLE "
29. " ESCRIBE LA IDEA PARA CIRCULARLA ENTRE LOS ESPECIALISTAS "
30. " (IRÓNICO) " ! ESO ES MUY BUENO, PERO NO PARA ESTA COMPAÑÍA!"
31. " LA NUEVA POLÍTICA DE LA COMPAÑÍA NO LO PERMITE "
32. " ÉSO ES COSA DE LA GERENCIA "
33. " DOCUMENTA BIEN LA IDEA PARA YO PASARLA MÁS ARRIBA "

34. " ÉSO ES PERFECTO, PERO NO TENEMOS TIEMPO AHORA "

35. " ÉSE HOMBRE NO SE LO MERECE DEBIDO A SU STATUS "

36. " NO ESTÁS DICIENDO NADA NUEVO "

37. " ¿ ESTÁS SEGURO ? "

38. " ¿ SABES LA IMPLICACIONES DE ÉSTO ? "

39. " LOS EXPATRIADOS NO PODÍAN HACER NADA ACERCA DE ESO "

40. " MEJOR DEJA ESO ASÍ "

41. " ESO NO HACE FALTA "

42. " NO LE BUSQUEMOS 5 PATAS AL GATO "

43. " MI GENTE ESTÁ MUY OCUPADA "

44. " ¿ ESTÁS CREYENDO EN PAJARITOS PREÑADOS ? "

45. " LA MISMA GATA PERO REVOLCADA "

46. " ERES MUY IDEALISTA "

47. " YO TE LLAMO "

TORMENTA DE IDEAS POR ESCRITO.

- LAS IDEAS SE ESCRIBEN.
- EVITA EL EFECTO DE LOS LIDERES DE OPINION.
- SE LEEN LAS IDEAS DE LOS DEMAS PARA GENERAR NUEVAS IDEAS.

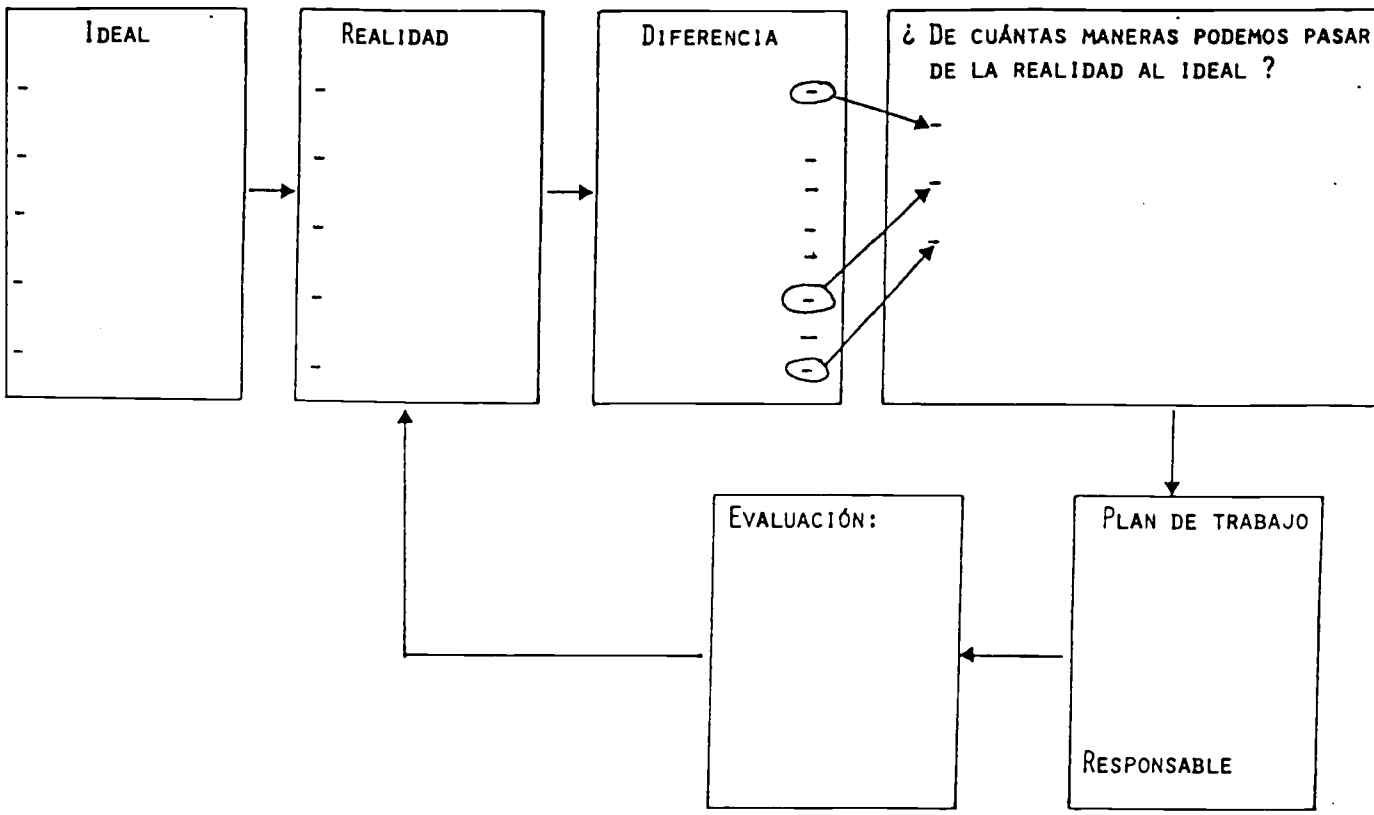
ABSTRACCION PROGRESIVA.

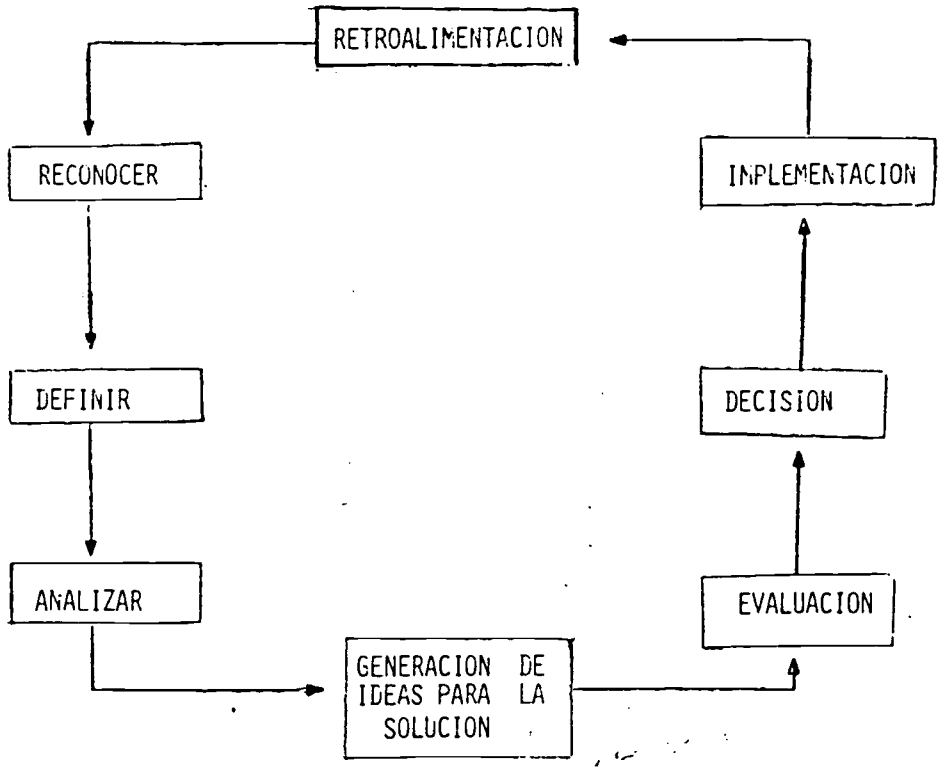
- SIMILAR A LA TORMENTA DE IDEAS.
- EN FORMA RECURRENTE SE ABSTRAE LO ESENCIAL.
- SE PREGUNTA ¿ CUAL ES EL PUNTO ESENCIAL ?

MODELO DE OPOSICION.

1) CREAR LA SITUACION IDEAL
2) VER LA SITUACION REAL.
3) CALIFICAR LA DIFERENCIA DE REAL A IDEAL.
4) SELECCIONAR LOS PUNTOS DONDE LA DISTANCIA SEA MAYOR.
5) TORMENTA DE IDEAS:
   ¿ COMO PODEMOS PASAR DE LO REAL A LO IDEAL ?
6) EVALUAR LAS IDEAS.
7) HACER PLAN Y DEFINIR RESPONSABLE.

MODELO DE OPOSICION





EL CICLO DE SOLUCION DE PROBLEMAS Y TOMA

INFOTEC

INNOVACION – INFORMACION – TECNOLOGIA

SAN LORENZO 153 11º PISO
APDO. POSTAL 17-194
TELEX 1777569 INFOME

MEXICO 12, D. F.
MEXICO 19, D. F.
TEL. 559-52 11

A: PARTICIPANTES DEL TALLER DE CREATIVIDAD

DE: SERVICIO INTERNO DE INFORMACION

Hemos considerado de interés ofrecerles una relación de títulos de libros que existen - actualmente en el mercado internacional, sobre el tema del taller.

Estamos en la mejor disposición de gestionar la compra de los que les interese adquirir, para lo cual les sugerimos utilizar el formulario de pedido anexo.

El tiempo de entrega de los libros solicitados es de aproximadamente 4 a 8 semanas.

LECTURAS SELECTAS

LA CREATIVIDAD Y LA ORGANIZACION

ESTADO DEL ARTE : METODOS DE GENERACION

BARRERAS A LA CREATIVIDAD

EJERCICIOS PARA DESARROLLAR LA CREATIVIDAD

PROCESO CREATIVO PARA SOLUCION DE PROBLEMAS

OPORTUNIDADES DE NEGOCIO

EVALUACION DE IDEAS

INTRODUCCION DE METODOS DE CREATIVIDAD A LA EMPRESA

MEASURING R&D PRODUCTIVITY

The ideal system measures quality, quantity and cost, is simple, and emphasizes evaluation of R&D outcomes rather than behaviors.

Mark G. Brown and Raynold A. Svenson

American industry will spend an estimated $67 billion in 1988 on research and development (*1*). Most companies, however, have no idea what they are getting for all this money. In fact, a study by Schainblatt revealed that only 20 percent of the R&D managers in the major companies he surveyed even measure the productivity of their R&D operations (*2*). Of the 20 percent that do measure productivity, only a few measure any kind of return on investment in R&D.

A good many scientists and engineers we have talked to think that it is impossible to effectively measure R&D productivity. In fact, the very act of measurement is thought to discourage creativity and motivation among high-level professionals. Many feel that management should just "have faith" that R&D is a good investment, without trying to measure it.

Some scientists and engineers are negative about measuring R&D performance for fear that such systems may point up their own inadequacies and lack of productivity. A good many others, however, have more valid reasons for being down on measurement and evaluation systems for R&D. Many attempts at measuring R&D productivity have been dismal failures. These failures have led many to erroneously believe that all measurement systems don't work. One company explained, "We tried measuring our researchers' productivity a couple of years ago—it caused them to churn out vast quantities of mostly useless research reports—quantity went up and quality went down."

Although R&D productivity is difficult to measure, many companies are now putting pressure on their scientists and engineers to not only produce new products and processes, but to demonstrate their value to the organization. R&D measurement and evaluation systems are no longer an experiment being tried by a few progressive companies; such systems are becoming a requirement. Upper management is becoming less content with subjective measures of R&D's contribution to the bottom line.

This article explains some of the major reasons why R&D measurement and evaluation systems fail, and presents some suggestions for designing a successful system. A prerequisite to understanding why R&D measurement systems succeed or fail requires looking at an R&D lab as a system that works within the macrosystem of the entire organization.

The R&D Lab as a System

All organizations are composed of systems working together to produce goods and services. An R&D lab is a system itself, with its own inputs, processes, and outputs. Figure 1 depicts a typical R&D laboratory.

1. *Inputs* are the raw materials or stimuli a system receives and processes. An R&D lab's inputs are people, information, ideas, equipment, facilities, specific requests, and the funds needed to complete various R&D activities. As a service department, much of the work R&D does is in response to specific requests from marketing, manufacturing, engineering, and other departments.

2. The *Processing System* is the R&D lab itself, which turns the inputs into outputs by writing proposals, conducting research, testing hypotheses, reporting results, and so on.

3. Typical *Outputs* include patents, new products, new processes, publications, or simply facts, principles, or knowledge that were unknown before.

4. The *Receiving System* comprises the various consumers of the R&D outputs. It might consist of marketing, business planning, manufacturing, engineering, operations, and other departments that make use of R&D's products and services. The Receiving System for R&D might also include such external users of its outputs as the academic community.

5. *Outcomes* are the accomplishments that have value for the organization. They are produced when the Receiving System accomplishes something with the outputs of the Processing System. If we were analyzing an automobile manufacturer using this model, the Receiving System would be consumers (people who buy cars) and the outcomes would

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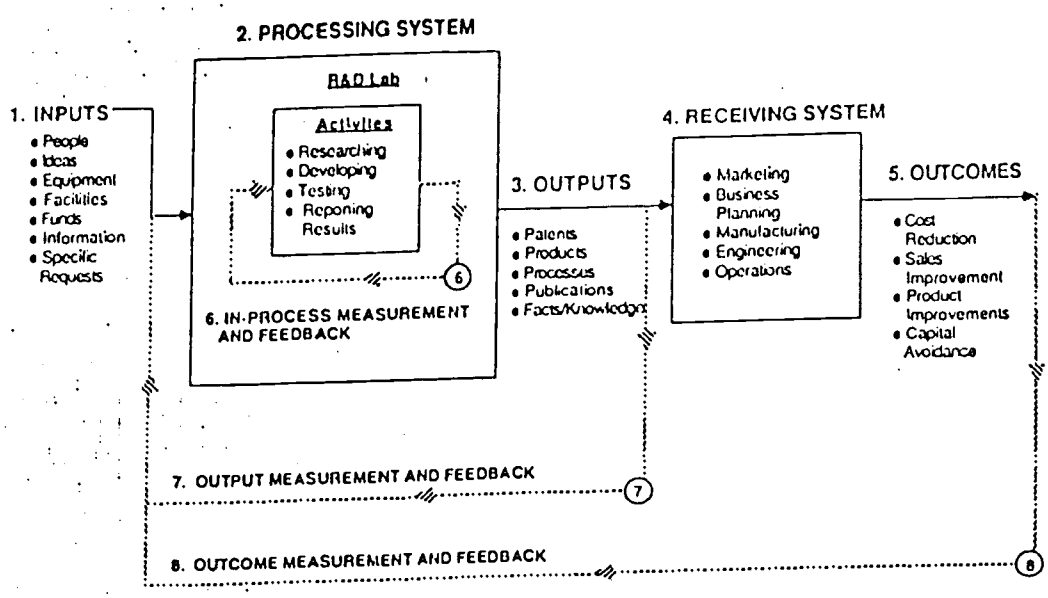

Figure 1.—The R&D laboratory as a system.

include sales volume and customer feedback. For an R&D lab in a profit-making organization, the outcomes are accomplishments such as cost reduction, sales improvement, product improvements, new products, market share, and capital avoidance.

6. *In-Process Measurements and Feedback* occur within the Processing System as the R&D lab measures itself and feeds back this information to its own people. Examples might be data on the number of research proposals written, the amount of the annual budget, the number of drafts required on a research report, or a project manager's comments on the first draft of a research proposal.

7. Outputs must be measured as well as process. The quality control department usually provides this type of measurement and feedback for a manufacturing operation. R&D outputs are also evaluated by a variety of outside sources (e.g., journal editorial boards, patent offices, etc.) as well as internal sources (e.g., R&D, management, engineering, manufacturing, etc.). Outputs are measured on three dimensions: quality, quantity, and cost.

8. Simply measuring outputs is not enough—outcomes must also be measured and the information fed back to the processing system. The real value that the R&D facility adds to the organization can only be assessed by measuring outcomes.

Why R&D Measurement/Evaluation Systems Fail

Too Much Emphasis on Internal Measurement.—The major problem with most systems for measuring R&D performance is that they rely too heavily on in-process measurement and feedback. Every R&D lab has systems for reviewing work at various stages to ensure quality and conformance to budget and schedule guidelines. Internal measurement and feedback is valuable and worthwhile, but it is dangerous to use only these measures in evaluating an R&D facility.

Laboratories that measure their success based on their own measures may appear to be doing a great job, without actually producing valuable accomplishments for their companies.

Too Much Focus on Behavior.—Behavior is a process or activity. Writing proposals, gathering and analyzing data, preparing reports, publishing findings, and developing technology transfer plans are examples of behaviors by individuals in an R&D facility. Because outcomes are not as easy to measure as number of parts produced or pages typed, many organizations have developed systems for measuring these activities or behaviors.

Hughes Aircraft Company conducted one of the most extensive studies of R&D lab productivity (*3*). One of the many important findings is a list of behaviors found in highly-productive R&D facilities. This landmark study has served as the standard against which many R&D organizations measure their own productivity.

There are several problems with this behavior-based approach:

- People can do all the "right" things and still not produce valuable results.
- A measurement system based on behavior causes

people to be overly concerned with the way work is done, rather than focusing on the outputs produced.

- The characteristics identified in the Hughes study that were correlated with productive R&D facilities may not cause high productivity. Correlation cannot be assumed to indicate a causal relationship.

- Behavior is difficult to measure accurately. Surveys and questionnaires are inexpensive and simple ways of measuring what people do, but they are extremely unreliable. Direct observation is the only relatively accurate way of measuring behavior, but it is expensive and time-consuming.

An example may help to demonstrate the danger of relying too heavily on behavioral measures. Consider two senior-level research scientists in the R&D lab of a major manufacturing company. The scientist we'll call Peter works an average of 60 hours a week, never misses a meeting, gets along with everyone, is a good project manager, meets his deadlines, and does a good job working with committees to review research projects and proposals. However, he has never done anything of great value to the organization, or made any significant contributions to the field.

The second scientist is the opposite. "Andrea" rarely works evenings or weekends, her desk is a mess, she frequently misses deadlines, does not participate in committees unless forced to, and is considered somewhat abrasive in her relations with others. However, she has obtained several patents, designed manufacturing processes that have saved the company millions of dollars, and is viewed as a "world class" expert in her field. She has published papers in the most prestigious journals, and is frequently an invited speaker at important conferences.

If we evaluated behavior, Peter obviously comes out as the superior employee. He does all the right things. Andrea's behavior is rebellious, uncooperative, and she seems to lack Peter's loyalty and dedication. However, she has accomplished some remarkable things, making significant contributions to the field and to her company.

A behavior-based measurement and feedback system rewards people like Peter and punishes people like Andrea. Obviously, we would like to see a laboratory full of people who behaved like Peter and produced results like Andrea's, but that is probably unrealistic. The ideal measurement system includes both measures of behavior or activity as well as measures of accomplishments or outcomes. However, the primary focus should be on results, with secondary focus on behavior.

Measuring Outputs of Questionable Value To the Organization.—With increasing pressure from management to demonstrate what the company is getting from the money it invests in R&D, many laboratories have begun measuring their productivity based on outputs. Productivity is measured as the ratio of the number of dollars of outputs produced to the number of dollars of inputs.

> ***People can do all the "right" things and still not produce valuable results.***

Typical outputs measured include the number of:

- Research proposals written,
- Papers published,
- Designs produced,
- Products designed,
- Presentations made,
- Patents received,
- Awards won,
- Projects completed,
- Books written.

Outputs such as these are easy to measure and better than simply measuring behavior or activities. However, without a measure of the quality and value of these outputs, as well as the quantity, the measurement system will drive the wrong behavior. An R&D facility can be extremely productive, when measured by the quantity of outputs produced, but still not do much to further the organization's business goals.

Measurement System Is Too Complicated.—As the methodological rigor and validity of a measurement system increases, the ease with which it can be administered usually decreases. Attempts to develop the "ultimate" system for measuring and evaluating R&D performance have often led to the development of impressive, but complicated systems no one can administer. Their failure often leads to the conclusion that all evaluation/measurement systems are worthless.

Complex measurement systems also cause information overload. Scientists and engineers whose performance is measured on 20–50 variables typically ignore most or all of the feedback they receive. Measuring people on too many variables is as bad as no measurement at all. Research on Management-by-Objectives indicates that if people are given more than six to eight objectives to accomplish, they ignore most of the objectives and concentrate on two or three they believe are important.

Measurement System Is Too Subjective.—Some R&D labs have developed systems for evaluating the behavior and outputs of their scientists and engineers that are more qualitative than quantitative. While quality and value are important dimensions of a researcher's work, they are difficult to measure objectively. Many qualitative evaluation systems use numerical scales such as the one in Figure 2 for

evaluating dimensions such as originality, utility, methodological rigor, etc.

The problem with such rating systems is that the scales are not defined clearly and they allow for a great deal of individual bias. A "10" for one person may be viewed as a "6" by someone else. Even though most individuals attempt to remain fair and objective, peoples' biases unconsciously affect their ratings.

Effective R&D Performance Measurement System

Obviously, the way to design a workable system for measuring R&D productivity is to avoid all the errors we have described. Here is a summary of the characteristics of an effective and workable system for measuring R&D performance:

1. *Focus on external vs. internal measurement.*—Internal measurement and feedback is important as an in-process quality control tool. However, for evaluation purposes, external measures should be stressed because of their increased importance and validity. Most of the R&D measurement systems described in *R&D Productivity* do not include components for measuring outcomes based on receiving system feedback (*1*). One notable exception is the system used to evaluate R&D performance at Alcoa Laboratories (5).

Alcoa's evaluation system is truly exemplary, with the focus being the outcomes produced by R&D outputs. Patterson not only describes how outcomes are measured, he explains how a dollar value is estimated for each outcome (5). For example, "capital avoidance" might be an outcome of a new process designed by the R&D lab. The dollars of capital avoided by the implementation of this new process is a much better measure than simply evaluating the number or quality of new processes designed. Although Alcoa Labs' system contains a few minor flaws, it is closer to the "perfect" R&D Measurement System than the approaches used by many other R&D labs.

2. *Focus on measuring outcomes and outputs, not behavior.*—A good R&D measurement system should be focused on outputs and outcomes, not the activities of scientists and engineers. Behavior may be important when evaluating an individual researcher, but not for measuring the performance of an R&D lab. Outputs should be measured along three dimensions: quality, quantity, and cost. Outcomes should be measured along the same three dimensions, with emphasis on return on investment.

3. *Measure only valuable accomplishments/outputs.*—A popular accomplishment index used in both academia and industry is a measure of the number of times an individual's research is cited in technical journals (6). However, a citation is difficult for an organization to place a value on. Only those outputs or accomplishments for which a value can be established should be used as measures. Porter describes a fairly simple and valid technique for estimating the value of research results (7). Schainblatt reports that one company he surveyed had developed an algorithm for evaluating the value of R&D outputs (*2*).

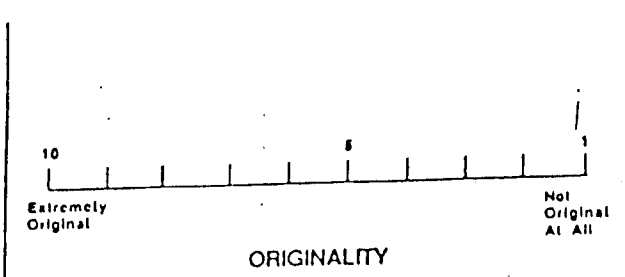

Figure 2.—Many qualitative evaluation systems use numerical scales for measuring such dimensions as originality.

The limitation of the techniques described in these articles is that subjective judgments are involved in the estimating processes. While it may be impossible to totally eliminate subjectivity, it should be remembered that the dollar value of outputs is only an estimate.

4. *Make the measurement system simple.*—Develop measurement indices that represent many aspects of performance, rather than different separate indices. The best measurement systems are based on the collection of data on six to eight key indices. These indices should be a combination of quality, quantity, and cost measures.

5. *Make the measurement system objective.*—Quantity measures are typically quite objective, but quality and cost data are often very subjective in systems for measuring R&D performance. While it is impossible to measure quality in a totally objective fashion, it is possible to minimize subjectivity in the design of an evaluation process. One simple way of making "soft" data more objective and credible is to use outside data whenever possible in assessing the quality of a researcher's work. For example, if you want to estimate the value of R&D's product enhancements, ask engineering or manufacturing to estimate these values, rather than having R&D managers estimate the worth of their accomplishments.

6. *Separate R&D evaluation.*—Research and development clearly perform different functions and produce quite different outputs. The primary output of Research is information or knowledge relevant to the company's business. This information is an input for Development, whose outputs are products and processes (new ones or enhancements to existing ones). Because of these major differences, any measurement and evaluation system should be designed to track different indices for research and development.

An Example From Electronic Products

We recently helped to design an evaluation system for the Product Development Facility of one of the country's largest manufacturers of electronic

Type of Measure	Measurement Indices	% Weight/ Importance
Cost	Final Product Cost (Primary index)	40
Timing	Product Design Cycle Time	20
Quality	Operating Cost	15
	Mean Time to Failure	5
	Mean Time to Repair	
Productivity	Estimated Value of Net Income Contributed to Total Development Cost	20
	Total	100 %

components and equipment. The productivity and quality of work performed by the scientists and engineers in this facility are evaluated on a few key indices. Every project is evaluated on only a few key variables: quality, quantity, timing, and cost factors.

A key feature of this evaluation system is that primary and secondary indices are identified for each project. For example, one project had "time to market" or "product development cycle time" as the primary index, because getting the product out before any competitors is considered more important than any other factor. On another project, the primary index is product cost. The major goal is to come out with a product that is less expensive than any of the competitors.

After identifying the primary index, secondary indices are specified and weights assigned to each index, based on its relative importance on that project. An example is shown in the table above.

This approach to evaluation allows objective measures to be used such as dollars and time. Quality is measured by individuals outside of the Product Development Department using a point system. The entire department is evaluated on the same types of variables as individual project managers.

The evaluation system described in the example meets all the criteria we have outlined, because it:

- Is based on external, not internal measures;
- Focuses on outcomes, not behavior;
- Includes only valuable accomplishments;
- Is simple;
- Is primarily objective, versus subjective.

In Conclusion

In spite of some initial failures, companies should not give up on evaluating their return on investment in R&D. Although a good system requires time and money to design, it is inexcusable that perhaps 80 percent of the largest U.S. companies don't measure the value they're getting for the almost $70 billion they will spend on R&D this year. If R&D is America's competitive edge against foreign competition, we ought to have a better idea of what we're getting for all those R&D dollars.

Of course, the real value of such an evaluation system is not simply the performance data collected. The value is realized when these data are used to shape the R&D program for maximum impact on business results. [*]

References

1. Wolff, M. F. "Forecast $132 Billion R&D Spending in 1988." *Research/Technology Management*, March-April, 1988, p. 2.
2. Schainblatt, A. H. "How Companies Measure the Productivity of Engineers and Scientists." *Research Management*, Vol. XXV, No. 3, May, 1982.
3. Rauld, R. M. *R&D Productivity*. Los Angeles: Hughes Aircraft Company, 1974.
4. *R&D Productivity*. New York: Industrial Research Institute, 1986.
5. Patterson, W. C. "Evaluating R&D Performance at Alcoa Labs." *Research Management*, Vol. No. 3, 1983.
6. Gibson, J. E. *Managing Research and Development*. New York: John Wiley & Sons, 1981.
7. Porter, J. B. "Post Audits—An Aid to Research Planning." *Research Management*, Vol. XXI, No. 1, January, 1978.

SUMMARY

The task of value analysis people is to assure that in every part of the business actions are accomplished that will allow the achievement of competitive costs. Often, in normal operation of good business, decisions and actions that seem quite proper are taken in one company area, such as management, sales, or engineering, and do indeed produce no extra costs there. However, they may and often do cause large amounts of unnecessary costs to develop in manufacturing, procurement, or elsewhere.

Experience has been gained with the value analysis group reporting to sales, engineering, manufacturing, procurement, accounting, and general management. Reporting to each has certain advantages, and reporting to the first five has a common disadvantage. In order to operate successfully and assure the business of proper costs of present and new lines alike, work must be done in, with, and for each of the decision-making areas named. The tendency is to develop the habit of doing much more thorough work in the area of reporting, using an important amount of time in so doing, while leaving other business areas without the assistance required to secure assured overall company results.

Often, after need becomes overcritical and assured results are essential, reporting is done to the man accountable in measured terms for earnings. This has proved very effective.

chapter 14

Essential Qualifications and Training for Value Analysts and Engineers

14-1 *Qualifications*

Successful accomplishment of some types of work requires logic and experience. Examples are the work of the plumber and the electrician. Other types of work require logic and experience supplemented by the development of certain skills. Examples are the work of the surgeon, the typist, the telegraph operator, and others. Then there are types of work whose successful accomplishment depends on experience and extreme creativity. Examples are certain types of art and some types of music production. Probably most other types of work activity fall in the range between these extremes.

As wider experience is gained, the specific qualifications for the relatively new vocation of value specialist or consultant will become more clear, more tangible, and more reliable. The indications of experience to date are that for the successful accomplishment of value work, the requirements are logic, experience, and great creativity, plus the development of certain mental skills such as ability to:

Make rapid and effective searches
Recall

Sort out useful information from what is not useful

Put together new, different, and useful combinations of ideas, materials, products, and processes to accomplish functions

Promptly select those combinations which are most apt to be good ones

All these abilities and skills, it will be seen, have a close tie-in with creativity and thus actually become the means through which creativity operates. It will also be noted that the special information and knowledge of value analysis operate directly to support the development and use of this skill.

14-2 *Traits, Characteristics, and Experience*

The necessary traits, characteristics, and experience, as spelled out and defined below, constitute essential qualifications for men engaged in value work.

Knowledge

For product work, a practical understanding of the properties of materials and their uses and of manufacturing processes, their potentialities, and their limitations is needed. For service work, the equivalent knowledge in that field is necessary.

Imagination

A good practical creative imagination commonly includes ability to retain extensive amounts of information concerning ideas for approaches and solutions to product problems, types of materials, properties of materials, processes, costs, and so forth, all arranged in a suitable order so that differing combinations may be creatively brought together and examined for applicability to problems at hand.

High Degree of Initiative

In value work, there are no definite beginning and ending points, and specific instructions on how and where to proceed are usually nonexistent. Further, this type of work is not well enough comprehended by general management for a rate at which it should be accomplished to be spelled out. For these reasons, it is essential that men in value work have a high degree of initiative, which must include what might be called self-drive, so that work activities will be started and carried through to completion with little if any supervision.

Self-organization

Initiative and drive are not enough; work must be effectively organized. Because of the lack of precedent and the lack of knowledge of organization for value work, conventional management supervision provides no experience for effectively instituting and executing the work. Therefore, the individual doing the work requires the ability to organize his activity effectively, as well as enough initiative to carry it out.

Personality

The work requires a mature, stable personality which is not easily discouraged. The entire field of activity in value work comes within the area of change. The amount of opposition to change usually prevailing cannot be conceived by anyone who has not attempted to operate in this area. The individual doing value work will be confronted with negative attitudes and delays of all sorts, with belittlement, and even with ridicule. The basic nature of anything new and the inherent attitude of the people with whom he will be dealing decree this. As Charles Kettering said, "The consensus of any group of people concerning something new in their field is always wrong." Or, as Thomas Edison said in 1926, "It requires about seven years for the average individual to accept a new proven solution to a problem." Because of this very exhausting aspect of value work, it is strongly recommended that it be performed by two or more persons working together. Each can then have an emotional environment of support, at least part of the time, which helps him feel that his work is a satisfactory and worthwhile endeavor.

Cooperative Attitude

A desire to work with others and a general knowledge of how to do it are other requirements, since the work is largely an endeavor based on working with others. It begins with acquiring an understanding of the job and proceeds by developing information which is often not available in ready form but which must be obtained if good value alternatives are to be produced. Knowledge concerning desired functions and methods for accomplishing them must be collected. Significant information must be communicated to competent commercial and technical people, and their wholehearted support (often with quotations) must be enlisted in expanding the area of knowledge in the direction of their skills through

the preparation of value alternatives. In many instances, the work includes the difficult assignment of getting information without giving offense.

Experience

All indications to date suggest that some five years of industrial experience in engineering, in manufacturing, or in special procurement dealing with particular specifications, opportunities, arrangements, and negotiations between buyer and seller (or equivalent experience) is essential. It seems also that actual experience in working with the normal situations that affect the development of value alternatives is required. These situations involve decisions between varying ways of accomplishing a function, between varying sources of supply, between differing systems of make versus buy, etc. Without experience along this line, there is a lack of background for efficient and effective search of possible combinations and for presentation of new and good value alternatives.

Belief in the Importance of Value

Starting with certain native inclinations and modified by childhood and business experience, any person develops interest in certain lines and disinterest in others. In essentially all cases, human beings are interested in food, although in some cases of unusually unfortunate environments, even loss of interest in food is developed by people. Some individuals are interested in flying, while others vow that they will resist it to the death. Similarly, some people develop an interest in providing new products through the development of new functions which their ingenuity can translate into a practical product. Other individuals develop an interest in making products more economical so that distribution may be widened with resultant benefits, not only to the company involved in selling the products, but to mankind in general, through more universal use. At the present stage of experience with value work, it appears that there exist marked degrees of difference in the beliefs of various individuals in the importance of low cost—or its equivalent, high value—in the general sense. Experience has shown that men who have strong belief in the importance of value are much more likely to be sufficiently motivated to develop the initiative, self-drive, and enthusiasm necessary to accomplish their work well. Such strong belief also seems to be an important factor in creating emotional stability in this very frustrating type of work. Hence the conclusion that "belief in the importance of value" is a significant trait.

An Understanding of the Management and Decision Process

It is also important to have a reasonable comprehension of the management and decision process. A host of good books provide this knowledge in depth. Management processes are not always optimum. For years, up to and including the present, decisions have not always been the best ones, but they are very real and very "controlling." Removing unnecessary costs often means patient, persistent, effective work for improvement in these areas.

14-3 *Training*

Five Essentials of Training

With the following training essentials, men will be prepared with understanding, with procedures and the experience of using them in disciplined thinking and acting, and with the confidence that grows only from a self-done task.

1. It must allow and cause each trainee to develop his own disciplined thinking.
2. It must provide understanding of reasons for excess costs.
3. It must provide disciplined procedures for identification and removal of unnecessary costs.
4. It must provide some new knowledge and much technique to be used in determining what knowledge to get, how to get it, and how to use it.
5. It must cause and allow each man to actually use the system and to secure better results than he thought he could.

How Much Training?

One week of training followed by six months of good on-the-job value work (preferably with other trained and experienced men), another week of training of a more advanced nature, often including the teaching of beginners), and then six months of additional value work are good.

A general conclusion is that with this year of alternating between on-the-job work and periods of training, men who have the proper characteristics, qualifications, and traits for the type of work involved can acquire a sufficient degree of knowledge and skill to be considered competent to start on a career of work as value consultants.

It is significant to understand that training is mandatory because value work is based on the use of different sets of techniques in a special way

and on the use of special knowledge. Without suitable training, the quality of the value work will degrade the profession for those competent qualified people who can accomplish results of the highest order.

An Effective 40-hour Training Seminar

Sessions can run continuously for a week or can be spaced.

Hours 1 to 4:	*Minutes*
Why the training?	15
What are we trying to do?	15
What is the value analysis and engineering system?	30
Why is the value analysis and engineering system needed?	30
Case studies	60
The vitalness of the right complete system	30
What must the system do?	30
Hours 5 to 8:	
All cost is for function	30
Case study	30
Identify, classify, and name the functions	30
Project work—get started, understand it	30
Identify, classify, name functions of project	90
Hours 9 to 12:	
Evaluate the function	30
Case study	30
Evaluate the functions of the project	60
Problem setting—function grouping and dividing	30
Case study	30
Problem setting on the project	30
Hours 13 to 16:	
Specific knowledge	30
Problem setting on the project	60
Problem solving—job plan	60
Project work—"What are we trying to do?"	15
"Information" step on project	45
Hours 17 to 20:	
Problem solving—job plan continued	60
Case study	30
Finish "information" step and get into "analysis" step of project	60
Decide and precisely define what problems are to be solved	30
Case study	30
Hours 21 to 24:	
Specialized knowledge	30
Group creativity	30
Creativity on project problems	60
More "information, analysis, and creativity" on project problems	60
Case study	30

Hours 25 to 28:	
Specialized knowledge	30
"Judgment" step of job plan	30
Project work—information, analysis, creative, judgment	120
"Development" step	30
Hours 29 to 32:	
Specialized knowledge	30
"Decision environment"	60
Case studies	30
Project work	90
Hours 33 to 36:	
Using the system to solve the hard ones	30
Overcoming roadblocks	30
Finish project work—get into shape for reporting	120
Examples of good reporting form	15
Questions and answers on reporting	15
Hours 37 to 40:	
Finalize results and suggestions and prepare charts, reports, presentations	120
Present reports	60
Discussion	30

SUMMARY

Value analysis is a system for use when better than normal results are needed. It is readily understandable that before an individual can be expected to achieve better than normal results, he needs the experience that enables him to produce normal results under the usual conditions. Five years or more of experience dealing with product or service factors of similar types are usually essential.

Broad knowledge in the field, a good practical creative imagination, a high degree of initiative, the habit of good self-organization, a mature personality, a very cooperative attitude, a belief in and "feeling for" the importance of low costs, and an understanding of the management decision process—all are essential for the optimum value analysis person.

An initial training period of 40 hours, of which about half is actual work, using the system, starts the use of the techniques. Six months of experience followed by another period of training usually results in enough familiarity with the system so that the individual can develop skill in value analysis.