Educational Program for Industrial Engineers
-Nurturing New Perspectives on Manufacturing Technology-

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ABSTRACT

In this paper, we propose the basic concept and result of an educational program developed for industrial engineers and managers in leadership roles who wish to create new values in manufacturing technology. The basic concept combines an intelligent knowledge-based approach with the *kaizen* activity program in a framework of new value creation and comparative advantage models based on the ABC-G network (Academia, Business, Consultants, and Governmental officers). The educational program is based on identifying the roles and responsibilities of each member of the

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ABC-G network in improving the competitive edge based on the *competere* concept. The case of the program developed could be identified the new values of the stakeholders of ABC network.

Key words: Industrial Engineering Education, Comparative Advantage, New Value Creation, ABC-G Network

1. INTRODUCTION

During the past two decades, international collaborative activities aimed at quality assurance in engineering programs have received increased emphasis and attention. These activities led to the formation of the Washington Accord [1-3], which now has eight signatory countries. On the other hand, the comparative advantages of various nations have been studied and reported by organizations such as the IMD [4] and by U.S. [5-6] and Japanese [7-8] researchers. Based on such research, we have developed a basic model and method to evaluate the comparative advantages of a business model of the global market based on the *competere* concept [9] to design a business model for creating new values as business output. The model and method were applied to evaluate Japanese industries and to clarify their weaknesses and strengths. We conducted a questionnaire survey among Japanese academicians, business executives, and consultants (ABC people), who stated that the main weaknesses of Japanese industry in terms of value-creating activities were leadership, management resources, and business processes. Among these, leadership was ranked the weakest value-creating activity [10,11]. The results of our research indicate that Japanese industries should maintain their advantage in the production process, employee relations, and physical values. They should also

develop new values, including both spiritual values and values outside the company.

This study aims to meet the following objectives:

(1) To propose the basic concept of an educational system which combines an intelligent knowledge-based approach with a *kaizen* activity program within a framework of new value creation and comparative advantage models.

(2) To develop an educational program for industrial engineers and managers in leadership roles who wish to create new values in manufacturing technology, and to discuss the results of the program.

2. MODEL AND ASSUMPTIONS

2.1 Leadership in Management Circles

The management system that enhanced the performance and profitability of Japanese companies during the post-war era can be characterized by the use of a scientific approach to management. The Plan-Do-Check/Action (PDCA) cycle was the core concept underlying a series of company-wide improvement movements that took place in Japan, including Total Quality Control (TQC) [12], Total Preventive Maintenance (TPM) [13], and Just In Time (JIT) [14]. The concept of PDCA also impacted the well-known global management standards that were introduced in Japan in the late 1980s, namely, ISO9000 and ISO14000 [15]. The concept of Scientific Management, which was invented by F.W. Taylor [16] in the U.S. in the early 20th century, underwent vigorous review and

refinement in a number of countries, including Japan, the U.S., and European countries.

Figure 1 shows a concept model of a PDCA cycle in management activity. In this figure, the term *destruction of the status quo*, first introduced by J. M. Juran [17], and was used as management's "mission" of the general management system of Japanese industries. Management's roles in destroying the status quo are the following:

(1) Destroy the status quo to achieve a new level in business.

(2) Maintain the results obtained from the destruction of the status quo.

In order to fulfill these roles, management must simultaneously implement destruction of the status quo (revision of the standard) and maintenance of the status quo (enforcement of the standard). In order to maintain competitiveness and avoid the risk of losing superiority in the market, it is essential to destroy the status quo and develop the systems and policies required to achieve a new level of growth. Organizational strength does not lead to the growth and development of the organization without destroying the status quo. On the other hand, the destruction of the status quo involves a certain degree of risk, requires a great deal of energy, and is often met by opposition. Maintaining the status quo involves the standardization and enforcement of the results obtained from the destruction of the status quo as well as risk containment. Prompt enforcement of new standards and the learning effect will give the organization extra strength to carry out another destruction of the status quo and heighten its risk-containment ability. However, such extra strength can

sometimes lead to supineness instead of growth, depending on how the strength has been produced and utilized.

Management should constantly heed the following two rules to fulfill its mission:

(1) Always have a critical mind. (What should be done to ensure the growth of the organization?)

(2) Develop systems and tools for solving problems.

Leadership capability is the ability of the organization to achieve its value objectives by means of accurately predicting social trends and promoting abroad acceptance of products/services. In other words, organization leaders are responsible for guiding key activities of the PDCA cycle in order to achieve the identified value objectives. While the conventional management strategy has predominantly focused on improving efficiency, the concept of leadership capability suggested in the present study emphasizes the need for an organization's leaders to define value objectives that are relevant to the expectations and requirements of a broad range of stakeholders and to guide corporate activities so as to achieve the value objectives. The paradigm for the 20th-century management circle focused on improving competitiveness by destroying the status quo in production efficiency and maintaining the new standard. However, the target for the destruction and maintenance of the status quo should be shifted from production efficiency to a new value in order to ensure continuous improvement and competitiveness in the 21st century.

Figure 1 Concept Model for the Management Circle

The methods of improvement in the *kaizen* (continual improvement) model can be classified as follows:

(1) Removing the cause of deviation from the standard (enforcement of the standard). Examples include 5S activity (***S**eiri*, ***S**eiton*, ***S**eiso*, ***S**eiketsu*, and ***S**itsuke*, Japanese words meaning *order*, *arrangement*, *cleaning*, *cleanliness*, and *discipline*, respectively), ISO9000-1994, and ISO14000.

(2) Optimizing the existing equipment and know-how and improving efficiency (improvement of methods for operating the system). The small-group activities (QCC [18], JK, and ZD) observed in TQC and TPM, which are effective company-wide improvement activities among Japanese industries, are the typical examples of this method of improvement.

(3) Destroying the status quo to establish a higher standard (improvement of the system). For this method, examples of methodologies can be found in policy-management concepts such as Quality Function Deployment [19], Business Process Reengineering (BPR) [20], and 6-Sigma [21].

2.2 Framework of the Comparative Advantages of a Business Model

The basic concept behind our research on competition is ***competere***, which is the Latin origin of the English word *compete*. C***om*** means *together*, and ***petere*** means *to search for an ideal of the world* [9]. We call the concept *symbiotic competition*, or *Kyousei/Kyousoh* in Japanese. A non-zero-sum game rather than a zero-sum game is assumed. Figure 2 contains an outline of the

concept.

Figure 2 The Concept of Symbiotic Competition

2.3 A Circuit Model for the Development of the Educational Program

Figure 3 is a flow chart called a circuit model [22,23], which represents the way in which the present educational program will be operated. Practical exercises are designed to nurture each participant's ability to implement *kaizen* and are thus focused on the problem-solving process. Many of the conventional approaches to problem solving may not be effective in actual work settings; in fact, problem solving and *kaizen* are often complicated processes that involve the use of many unconventional approaches. As shown in Figure 3, the learning cycle for the educational program consists of three processes: learning through lectures, understanding through seminars, and creating knowledge through practical exercises. The participants in the program may use conventional individual and group approaches. As they use unconventional approaches in a workplace setting, however, they will begin to understand the limitations of the conventional approaches. The former process is learning and understanding; the latter is creating. The above learning cycle will be repeated several times (one learning cycle per sub-theme) during the course of the program. When the participants complete the program, they will repeat the learning cycle to assess their understanding.

Figure 3 Circuit Model for the Educational Model

3. CASE STUDY OF AN EDUCATIONAL PROGRAM FOR INDUSTRIAL ENGINEERS

3.1 Goal

This educational program is intended for individuals who are interested in designing a manufacturing process for companies that manufacture industrial machines. The goal of the program is to help such individuals acquire sufficient knowledge and skills to ensure total optimization (instead of partial optimization)[24] of all processes and operations, as well as to facilitate continuous improvement in the workplace. Total optimization can be defined as optimization of quality, cost, and lead time through the improvement of multiple processes and operations.

This educational program, which reflects the characteristics of manufacturing technologies and practices in the Hokuriku District of Japan, will be implemented by the end of March 2006 in close collaboration with the relevant local manufacturing companies. The program has been approved by the Ministry of Economy, Trade, and Industry. Provided below are the objectives and an outline of this educational program:

(1) Objectives

The aim of this educational program is to provide participants with the knowledge and skills necessary to manage manufacturing processes employed by small- to middle-size manufacturers of

industrial machinery in the Hokuriku District of Japan. Classroom instruction as well as practical exercises will focus on the following:

1) Made-to-order manufacturing and flexible manufacturing systems, both of which are implemented widely by manufacturing companies in the Hokuriku District to control quality, cost, and lead time.

2) Total optimization (instead of partial optimization) of all production processes.

3) Continuous improvement in the workplace.

(2) Outline

By the end of March 2006, instructional materials will be created, and the proposed plan and strategy for designing and implementing this educational program will be evaluated.

The instructional materials will cover quality management (QM), creative manufacturing (CM), and knowledge-chain management (KCM). Each of these topics will be covered in 50-70 hours of classroom instruction (lectures + seminars/experiments) and practical exercises. The instructional materials will be developed in collaboration with the relevant manufacturing companies and will consist mainly of a series of problem-solving examples relevant to process control practices. Process control usually begins with the negotiation of price and delivery time for a given product and ends with the training of machine operators.

A plan and strategy for designing and implementing the educational program will be developed,

reviewed, and evaluated by the Program Development Committee, which will consist of registered management consultants, an information technology coordinators' group, and manufacturers of construction machinery, weaving machinery, machine tools, and functional parts that have manufacturing facilities within Ishikawa Prefecture, Japan. The manufacturing processes employed by these companies are relevant to the content of the educational program.

The instructional materials will be developed one by one in order of priority (i.e., QM, CM, KCM). The focus of the plan and the strategy for designing and implementing the educational program will be shifted as necessary. Each stage of program development will be reviewed and evaluated by the major industrial organizations (e.g., Human Resource Development Sub-Committee of Ishikawa Tekkokiden Association (ITA)) located within Ishikawa Prefecture in order to ensure and maximize the objectivity of the program content as well as to promote awareness of the availability of such a program.

3.2 Knowledge and Skills Required to Implement Process Control in Industrial Machine Manufacturing Facilities in Hokuriku District

During February and March 2005, a survey was conducted among 500 companies that are members of ITA in order to identify the knowledge and skills required to implement process control in industrial machine manufacturing facilities in Hokuriku District (response rate: 33%). The survey results can be summarized as follows:

(1) Knowledge and Skills Required to Control Manufacturing Processes

Skills and knowledge in quality control, cost control process synthesis, and production volume/lead time control were evaluated. Skills and knowledge in quality control were selected by 31.1% of the respondents as important aspects of manufacturing processes, whereas skills and knowledge of cost control were selected by 22.0%.

(2) Skills and Expertise in Information Systems

Respondents identified skills and expertise in the following programs and tasks as most important: Microsoft Excel (37.9%), product/process design systems (e.g., 3D-CAD, PDM; 22.9%), and constructing a database (19.0%). Very few respondents expressed a need for other computer skills.

(3) Ability Required for Successful Job Performance (In Order of Priority)

The ability to design manufacturing processes and expertise in manufacturing technologies was considered most important (25.6%), followed by the ability to improve, reform, and innovate work procedures (24.2%) and the ability to manage materials, procurement, and purchasing (18.8%). Less than 10% of the respondents expressed a need for other abilities.

3.3 Content of the Educational Program

The program will be developed based on the knowledge and skills required to implement

process control in facilities that manufacture industrial machines. Table 1 outlines the content of the program.

Table 1 Subjects and Learning Objectives

3.4 Cooperation among Members of the ABC Network in Developing and Implementing the Educational Program

Figure 4 illustrates the cooperation among business people, academicians, and consultants in developing and running the educational program. In this figure, the three stakeholders in the program have human resource development as their objective. Members of both business and academia focus on collaborative development and sharing of instruction materials. Also, both academicians and consultants share methods to promote *kaizen* in the workplace. Consultants and business people share methods to introduce *kaizen* to the workplace. As a result of symbiotic competition based on *competere*, the values pointed out in "IN" of Figure 4 can be created through the educational program.

Figure 4 Value Creation and Resource Allocation within the ABC Network in Running the Educational Program

4. CONCLUSION

This paper describes the basic concept and result of an educational program developed for industrial engineers and managers in leadership roles who wish to create new values in

manufacturing technology. The basic concept combines an intelligent knowledge-based approach with a *kaizen* activity program within the framework of new value creation and comparative advantage models. The educational program can facilitate the creation of new values by collaboration among members of the ABC-G network based on *competere*.

Further research will be used to develop a feedback program to evaluate outcomes and to improve and create new values for the educational program.

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Figures and Tables

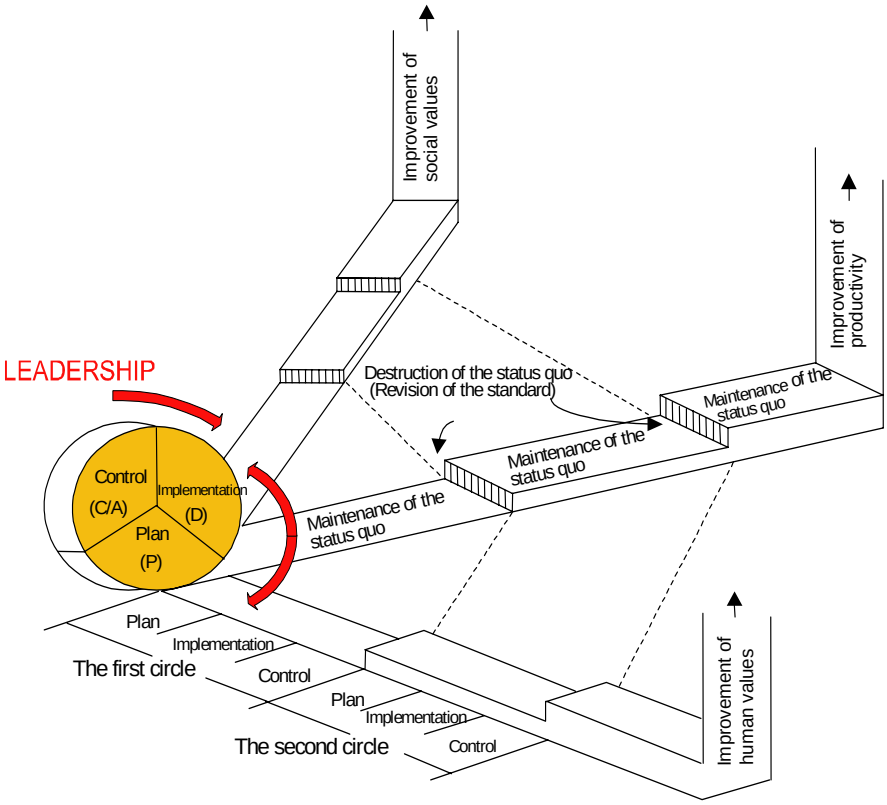

Figure 1 Concept Model for the Management Circle

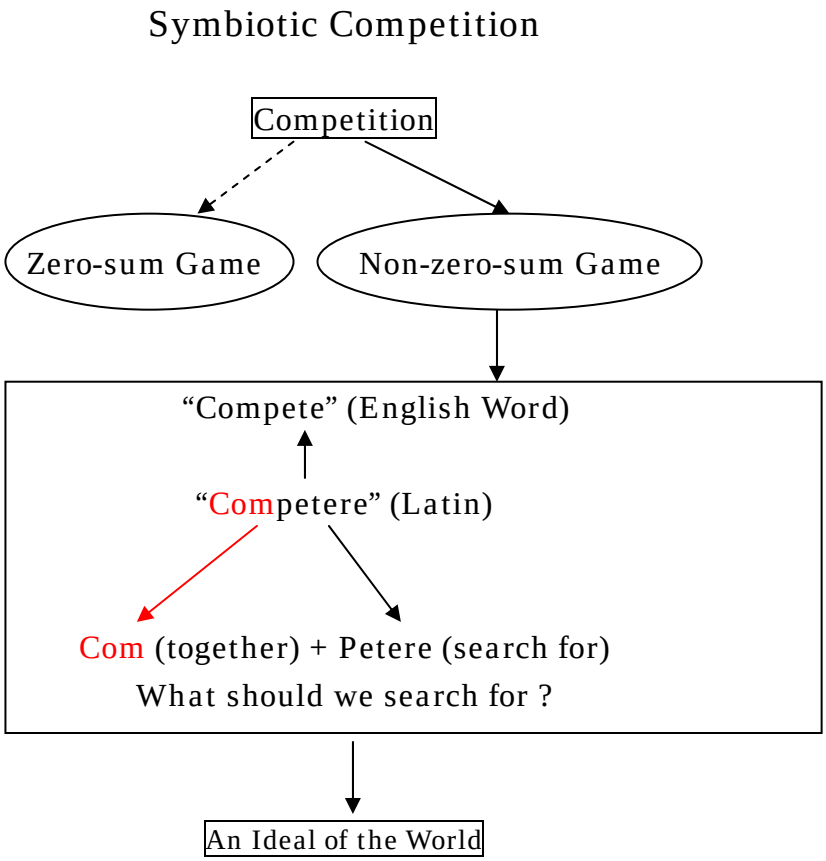

Figure 2 **The Concept of Symbiotic Competition**

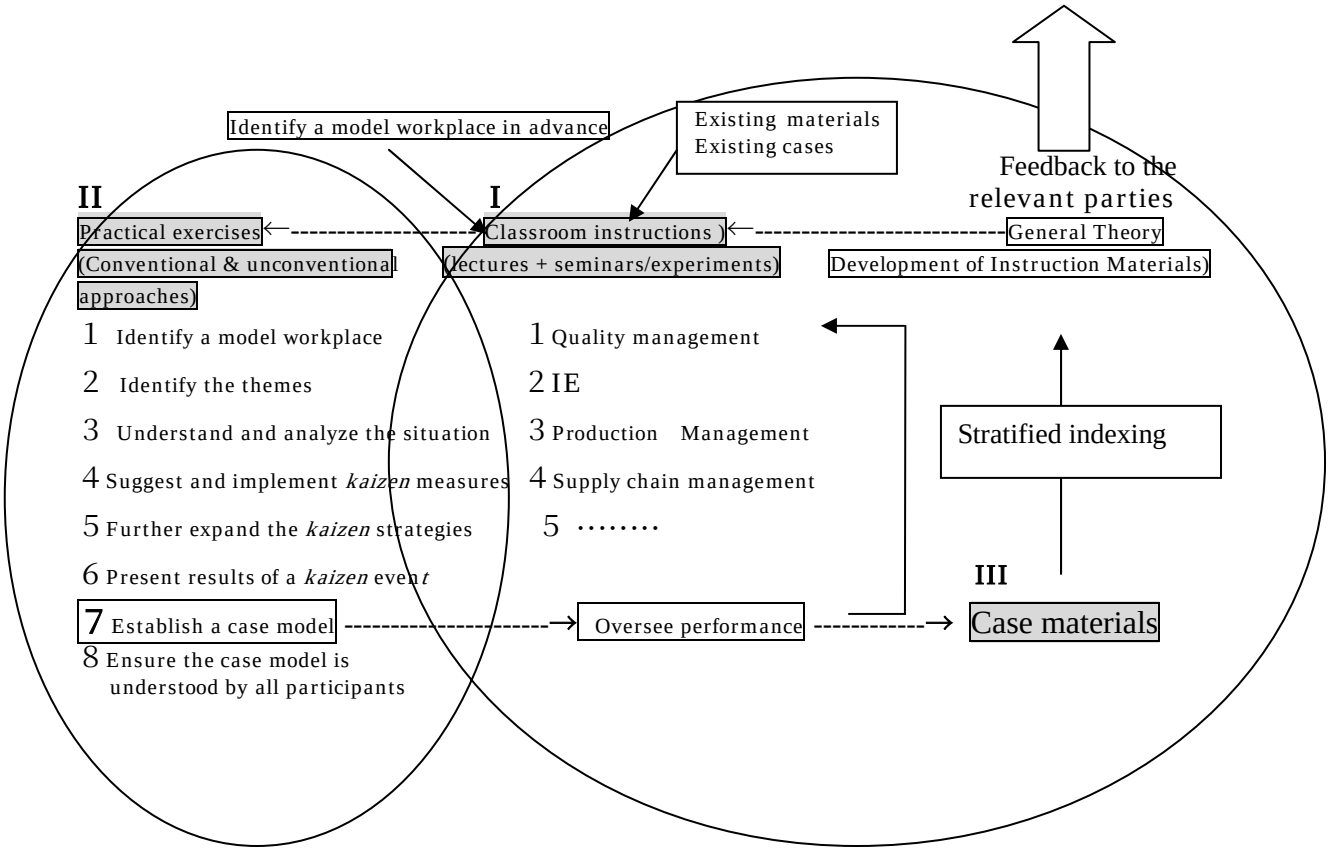

Figure 3 Circuit Model for the Educational Model

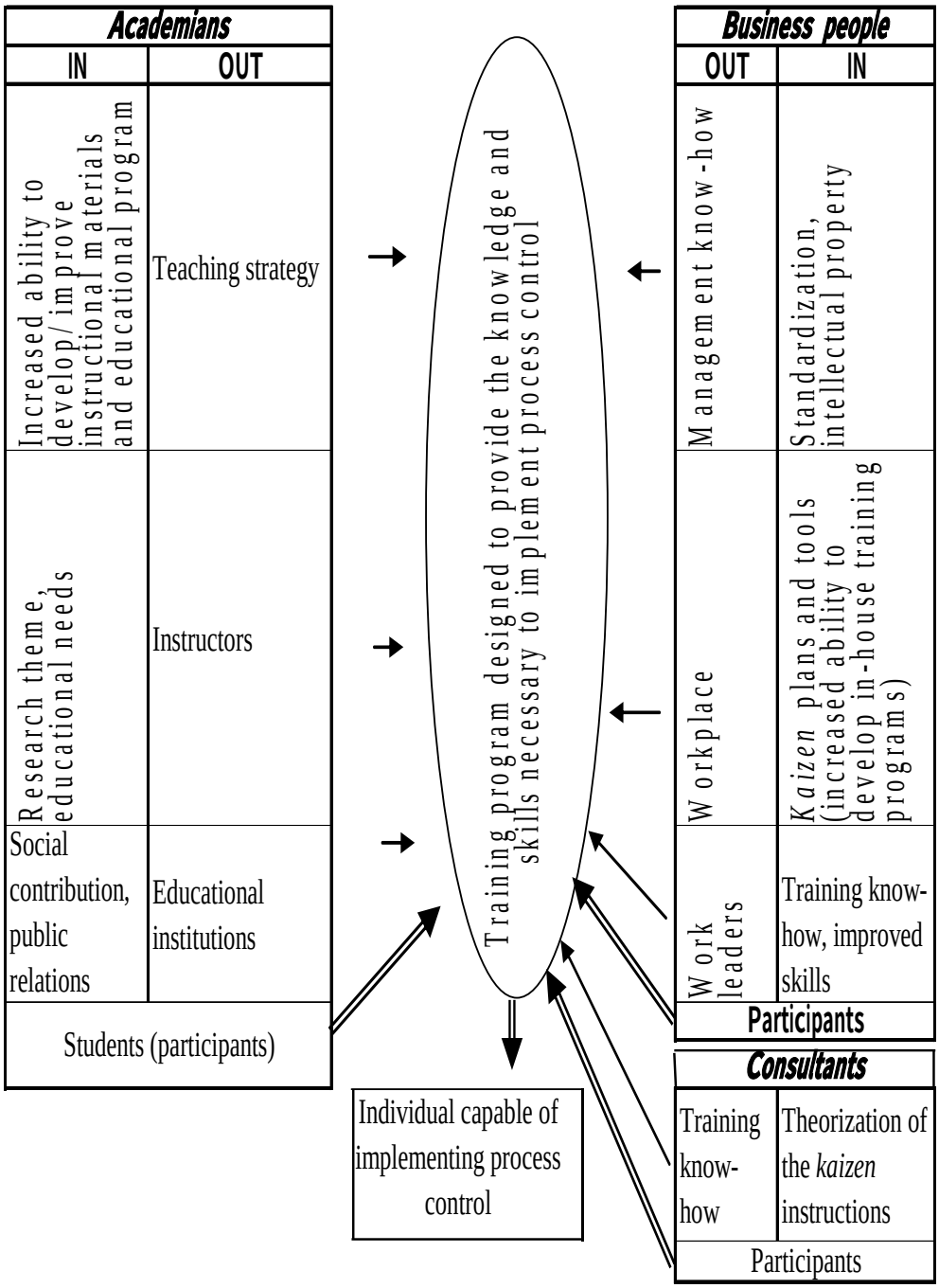

Figure 4 Value Creation and Resource Allocation among the ABC Network in Running the Educational Program

Table 1 Subjects and Learning Objectives

Step	Subject	Learning Objective
Step 1 (April - June)	QM	Ability to use appropriate measures to implement QM whenever necessary in order to ensure high-quality products and customer satisfaction. Ability to transfer QM know-how to a successor.
Step 2 (September - November)	CM	Ability to do the following in order to be able to identify important and fundamental problems that exist in the workplace and make necessary improvements: 1) Identify key areas for improvement in a given workplace. 2) Understand and analyze the current situation in the workplace. 3i) Propose specific plans for *kaizen* (continuous improvement). 4) Communicate *kaizen* plans to relevant workers and, when necessary, show them how to implement individual *kaizen* actions, provide necessary explanations, and encourage them to implement the actions. 5) Do all of the above even when assigned to a different workplace.
Step 3 (December - February)	NCM	Ability to accumulate and integrate knowledge regarding the following: 1) Product planning. 2) Product design and development. 3) Manufacturing through the use of information technology to create value for customers.