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EVOLUTION OF THE BUSINESS, EDUCATION, DESIGN AND RESEARCH (BEDR) ORGANIZATION THROUGH THE DEVELOPMENT OF A GLOBAL GROUP NETWORK

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In one of my earlier works presented here at the Academy of Athens I described the airplane as a vehicle for bringing people together for technological, educational and social developments (1). Using the airplane as a backdrop, I was able to frame the operations of my laboratory and describe the teaming processes that were beginning to come together. The original teaming relationship alluded to in that earlier work between the Boeing Commercial Airplane Group, the large Japanese chemical concern, Toray, and the Polymeric Composites Laboratory at the University of Washington *still* survives in a very robust fashion to this day. This team, comprised of hundreds of people, was responsible for the structural composites present today in the floor beams and empennage of the Boeing 777 part of which is shown schematically in Figure 1. These composite materials were able to reduce the weight of this newest vehicle in the Boeing family, thereby reducing the cost of airline operation and travel for the airlines and customers. I am beginning this talk with this illustration to demonstrate the efficacy and power of teaming relationships.

However, my work, whether it was on the viscoelasticity of thermoplastics (2) or Co-opetive team education and learning at the University of Washington (3), has always focused on the processes required for action as opposed to the product resulting from action. The team described above may have accomplished notable results, but the real accomplishment came at a breakthrough workshop where a diverse group of people I assembled was able to discover the requisite environment for the assembly and operation of such teams. And I am here tonight to outline the processes that bring together teams and allow them to function successfully. The description of these processes will be punctuated by two primary examples, which were still related to the airplane. I will also use my most recent workshop, which was focused on both management of technology and polymer fundamentals, as an illustration where I have reached beyond the airplane and begun to expand this teaming methodology into a wider range of fields.

But first, I must digress to describe an event that resulted in finding a key piece of the teaming process. Shortly after the presentation I mentioned earlier, I was invited in 1995 by the Boeing company to partake in a class designed to teach pilots how to fly the Boeing 757/767 family of jetliners. The class was centered on a flight simulator that allowed the user to effectively step inside a cockpit and fully experience a virtual reality of flying a commercial jet. This was the fastest, most effective mode of teaching I had ever been exposed to, and I titled it experiential learning because it allows you to learn through an experience without necessarily having been trained in the underlying fundamentals of the subject. This can be most succinctly described by the phrases from the ancient Chinese philosopher K'ung Fu Tze shown in Figure 2. Experiential learning is closely related to game based learning, which is currently being explored as a very powerful pedagogical tool in fields as wide ranging as nursing and public policy (4, 5). Since my experience with the flight simulator, I have made it a point to include experiential learning in every teaming process.

The 737 flight simulator has continued to evolve since my initial exposure to the task (Figure 3), and in the same way, my teaching style has been evolving as well. Due to my initial exposure to experiential learning, I began experimenting with the working relationships between professors, industrial experts, student facilitators, such as teaching assistants, and students. The evolution of these relationships is depicted schematically in Figure 4 and described below. Scenario 1 shows the relationship in a traditional classroom, where the professor is in direct contact with the students through lectures, and the teaching assistant plays a supporting role mainly outside of the classroom. The role of the teaching assistant –a graduate student– is to grade exams and assignments, and to hold office hours to help explain the professor's lectures. As a result, the students and the teaching assistants learn only about what the professor chooses to lecture and the material he passes on.

Scenario 2 represents the first attempt to change the traditional way the classroom was run in Scenario 1. The new format consisted of student learning teams, student facilitating teams comprised of senior graduate students, and professor/expert teams, the latter providing facilitation only; no formal lectures were given. If the students requested a lecture from the professor/expert, it was given in discussion format to maximize the learning process. The student facilitating teams and the professor/expert teams spent about the same amount of time assisting the learning teams. Students were largely encouraged to determine what they wanted to learn in addition to the fundamental material of the course. The resulting interactive learning environment encouraged all three teams to increase the breadth and depth of their knowledge. This scenario emphasized individual and team assessment; both the students and facilitating teams were evaluated. However, after an evaluation of the course it was determined that a communication gap existed between the student facilitating teams and the professor/expert teams, which did not provide adequate structure for technical education. The following scenario was created to form a more structured base for teaming classes.

Scenario 3, modified by the professor/expert team, was designed so that the student facilitating teams could manage the class for the quarter, assigning reading, grading exams, and giving the course direction. The student learning teams' role was unchanged from the previous scenario; they were present to acquire knowledge and to stimulate their own learning.

This scenario focused on student facilitating teams, the senior graduate students, interacting with the student learning teams and receiving limited input from the professor. Although this system was more structured than that in Scenario 2, it still did not provide satisfactory framework for the learning process because of insufficient interaction between both student teams and the professor/expert team. It was realized that although students should not be controlled by the professor/expert as they were previously in the traditional classroom, they required more direct aid from the professor/expert in the teaming environment for optimal learning to occur (6).

Scenario 4 depicts a more balanced learning environment evolved from Scenario 3. Class structure was strengthened while maintaining a customer (student) driven learning environment in a team atmosphere. This was accomplished by providing equal interaction —whether during class time or outside of the classroom– between student learning teams, the professor/expert team, and graduate student facilitating teams. The educational process proceeded in a more methodical manner, increasing the students' learning and the efficiency of all the facilitation involved.

The final scenario, scenario 5, included the positive attributes of scenarios 1 through 4 and added the key aspect of experiential learning. In addition to attending class sessions, students worked in teams on projects grounded in real-time and designed to strengthen their active participation in the learning process. Through their project work students generated their own questions, again reinforcing the idea that the students determined the curriculum. To help facilitate this educational process, students outside of the engineering discipline were brought in from majors such as Operations Management and English to create rich and diverse teams. From this, students were able to draw on each other's core knowledge and learn from one another while at the same time learning together in class. This is where the professor/expert team became increasingly more of a catalyst rather than the omniscient educators; the team's job was to guide and facilitate the learning process and not to dictate its outcome.

The final scenario in Figure 4 also included a vital aspect of interaction between teams. Instead of each team interacting with another team, all teams now associate together at the same time through projects, sharing background information, and engaging in hands-on experiments. This final process has proved to be extremely effective at increasing student participation, teamwork, and communication skills, all while strengthening their traditional fundamental knowledge. The scaling for this process –and for teaming in general– is comprised of a compete-and-collaborate-environment, heterogeneity, and a global scope.

An undergraduate capstone design class in the Chemical Engineering Department at the University of Washington executed one of the most poignant examples of what can be accomplished through experiential learning in the teaming environment that was just described. As stated earlier, in contrast to other professors in this department at the University of Washington, I open these classes to students from many disciplines outside Chemical Engineering, including such diverse departments as English, Operations Management and Law, and challenge the students to complete a project in only 10 weeks. Most importantly, all these projects are posed by industrial sponsors who have a very serious stake in the outcome of the class. Prior to a class in 1998, I was consulting to Phil Condit, CEO of the Boeing company on the future of the Boeing Business Jet, a modified 737 for business travel. A question was raised about possible improvements to the shower system on the Business jet. At that time, a shower on a plane required 60 gallons of fresh water and two holding tanks in the cargo, which made for a significant loss of volume in the cargo hold and a large amount of extra weight, translating into poor airline performance. The senior design class of 1998 was challenged to improve this system, and ten weeks later I stood looking at the first working prototype of the recirculating shower system. This shower, which has since found its way onto the Boeing Business Jet, only required five gallons of water and dit not need a holding tank in the cargo hold. This elegant solution, shown in Figure 5, took care of both major problems facing the old shower design; furthermore, it was built from off the shelf technology, which means that development costs and the cost of scaling this technology up out of the laboratory was relatively low. Again, it was a teaming environment that was able to deliver results beyond expectations in very little time.

Approximately one year later during the spring of 1999 I organized a Life Long Learning symposium. At that symposium, we were discussing what the key events were and what was distinctly different about the environment that had allowed the development of the recirculating shower to come to fruition so quickly. After a lengthy brainstorming session, it became apparent that the environment was one that was equally focused on business, education, design and research. These four components had been harmonically balanced, all competing for the attention of the participants, yet at the same time spurring the students to create the recirculating shower by working together. That workshop showed me that the Polymeric Composites Laboratory was actually not the cornerstone of the teaming environments, but rather a very important node in the Business, Education, Research and Design (BEDR) Organization I had created.

BEDR was established to provide an exchange ground between academia and industry. As shown in Figure 6, at the base of this global group network, there are people, equipment, and projects. These three elements interact together in an environment that is controlled by the 5S and 6σ principles (7, 8). According to Nishibori and Tataku, 5S is a philosophy that allows for a clean and ordered working environment (7). Developed and successfully implemented by the Japanese industry, the 5S philosophy has so far not been achieved in an academic environment. In its effort to apply and master this philosophy within the boundaries of a non-profit organization, the Polymeric Composites Laboratory (PCL) combined the 5S principles with that of the 6σ theory. Developed by Motorola in the 1990s, the 6σ theory implies streamlining any process until it is flawless (8). Basically, this means that there is no tolerance for error or deviation from set norms and standards. My governing principle of the double trinity, which I applied earlier to leadership and technical concepts can be generalized as shown in Figure 7 and applied to the 5S and 6σ concepts as shown in Figure 8 (9, 10). By associating the 5S and 6σ principles with a house base and an enterprise base connected by scaling principles, the PCL was successful in demonstrating that both philosophies could be applied to a non-profit environment.

A schematic drawing of a virtual cross section of this organization is presented in Figure 9. Not surprisingly, this figure can be easily compared to earlier work performed on the network development of high performance thermosetting polymers for aerospace applications (11). As Figure 9 shows, the BEDR organization is a global group network of organizations, and more importantly individuals who are willing and able to advance and aid a further understanding of the teaming process. These different institutions are able to come together and form teams that are able to achieve far more together than they ever were able to do so standing alone. However, it is not enough for these groups to simply co-mingle. Amazing accomplishments are made when ways are devised to harness the network and subsequently create and harvest value from its nodes. To this end, it is necessary to note that the organizations in this figure are divided into two main categories: for profit institutions, such as Boeing Business Jets, United Airlines and Toray, and non-profit institutions, such as the Academy of Athens, and the University of Washington.

At this point, a sweeping, but necessary generalization can be made about these groups of institutions, depicted in Figure 10. The for-profit organizations are historically more capable at performing the functions of business and design. Consider the Boeing Commercial Airplane group, or Toray; these industrial concerns have been innovating and designing new products since their inception, and they have been turning a profit while doing so. Clearly demonstrating that business and design are effectively their core competencies. The non-profit organizations, on the other hand, are historically more capable at performing the functions of education and research. Here at the Academy of Athens, an innumerable amount of people have been educated and research in a most diverse range of fields has been performed for literally centuries. The BEDR Organization serves as a portal for bringing together the business and design strengths of the for-profit organizations and the education and research strengths of the non-profit organizations. Through these interactions, these organizations grow tremendously in breadth of knowledge as for-profit organizations are stretched with education and research challenges and non-profit organizations are stretched with business and design challenges.

An example of one such team that forced all parties involved to form a sound team, and grow together was a collaboration between the University of Washington, Bowne Internet Solutions, Boeing Business Jets and Editoriale Domus. In this project, a global competition was launched, challenging design firms across the globe to submit suggestions for revolutionary interiors in a Boeing Business Jet. In this competition, 9 judges from 7 different countries examined 180 entries form across the globe. After down-selecting to the best 39 entries, the committee chose the 5 best, which were awarded a total of US$45,000, and a publication announcing the winners was published in august of 2000, the cover of which is shown in Figure 11. This team was able to demonstrate the ability of this BEDR Organization to stretch beyond the boundaries of the University as a launching point for technical innovation, and show that this same environment could be used for design innovations.

The most recent endeavors of this teaming oriented organization have reached beyond the realm of the airline industry and into the medical field. In my most recent workshop, held at the University of Washington in early February, I challenged the class to create a new adhesive material capable of arresting intense bleeding from the tailbone, which can occur during a poorly executed colonectomy. Through the course of the workshop, it was shown that the airline and medical industries actually share many similarities as shown in Figure 12. Most importantly, the process for introducing new materials onto an airplane are similar to the process required for introducing a new drug or medical device for use in the public. Both processes are constantly working with regulatory agencies to produce the safest, most effective and cost effective solutions for the public.

I cannot stress enough the importance of the process, in this day and age when researchers and businesses are tending to focus so narrowly on the customer and product. As shown in the value base of my double trinity of leadership in Figure 13, one must, at the very least, place an equal focus on the process, customer and product. The above analogy between the aviation and medical industries points directly to the need for continued academic concentration on processes in general. To this end I have recently been asked to sit on the advisory board of a new non-profit organization in France called the Process Administration Institute (P.A.I.); the newest node in the BEDR Organization's global group network. This organization has been chartered to understand and improve the efficiency of processes, regardless of the industry, product or customer the process is associated with. In the future, teaming will continue to play a dominant role in the development of both for-profit and non-profit organizations, and this can be most effectively accomplished in an environment that remains equally focused on business, education, design and research.

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ΠΕΡΙΛΗΨΗ

Ἡ ἐξέλιξη τοῦ Ὀργανισμοῦ «Ἐπιχειρήσεων, Ἐκπαίδευσης, Σχεδιασμοῦ καὶ Ἔρευνας» (BEDR) μέσα ἀπὸ τὴν ἀνάπτυξη ἑνὸς παγκόσμιου δικτύου

Σὲ μία ἀπὸ τὶς πρῶτες μου ἐργασίες περιέγραψα τὸ ἀεροπλάνο σὰν ἕνα μέσο ποὺ φέρνει τοὺς ἀνθρώπους πιὸ κοντὰ γιὰ τεχνολογικούς, ἐκπαιδευτικοὺς καὶ κοινωνικοὺς σκοπούς. Ἡ ἀρχικὴ ὁμάδα ἐργασίας, ποὺ περιελάμβανε ἐργαζόμενους τῆς Boeing Commercial Airplane Group, τῆς ἰαπωνικῆς χημικῆς βιομηχανίας Toray καὶ μέλη τοῦ Polymeric Composites Laboratory τοῦ University of Washington, ὁδήγησε στὴν δημιουργία κατασκευαστικῶν στοιχείων ἀπὸ σύνθετα ὑλικὰ ποὺ χρησιμοποιοῦνται σήμερα στὴν ἀεροναυπηγικὴ βιομηχανία, ἀλλὰ καὶ στὴ συνέχιση τῶν ἐπαφῶν καὶ τῆς συνεργασίας τῶν μελῶν ὡς καὶ τὶς μέρες μας.

Ἡ ἐργασία μου, ἐκτὸς ἀπὸ τὶς τεχνολογικὲς καινοτομίες ποὺ περιλαμβάνει, ἑστιάζεται καὶ στὶς διαδικασίες ποὺ ἀπαιτοῦνται γιὰ δράση, σὲ ἀντίθεση μὲ τὸ προϊόν, σὰν ἀποτέλεσμα τῆς δράσης, μέσα ἀπὸ τὴ μεθοδολογία ποὺ πρέπει νὰ ἐφαρμόζεται γιὰ τὴν εὔρυθμη λειτουργία μιᾶς ὁμάδας.

Βασικὸ στοιχεῖο τῶν διαδικασιῶν μιᾶς ὁμάδας ἀποτελεῖ ἡ ἐμπειρικὴ μάθηση καὶ ἀφοῦ καὶ ἡ τελευταία ἀποτελεῖ στοιχεῖο τῆς ὁμάδας ἄρχισα νὰ πειραματίζομαι εἰσάγοντάς την σὲ κάθε ὁμάδα μὲ τὴν ὁποία ἐργαζόμουν. Ἀποτέλεσμα αὐτῆς τῆς προσέγγισης ἦταν ἡ ἐξέλιξη τῆς διαδικασίας τῆς ἐκπαίδευσης ἀπὸ τὴν κλασικὴ ἐκπαιδευτικὴ δραστηριότητα στὴν ἐμπειρικὴ μάθηση ποὺ ἐμπλέκει ἴδιες ἀσχολίες γιὰ τὰ μέλη τῆς ὁμάδας εἴτε αὐτὰ εἶναι καθηγητές, εἴτε σπουδαστές, μέσα ἀπὸ τὴν κοινὴ ὁμαδικὴ δράση. Παράλληλα οἱ ὁμάδες, ἀντὶ νὰ ἐπικοινωνοῦν ἡ μία μὲ τὴν ἄλλη, ἐμπλέκονται ταυτόχρονα σὲ ἐργασίες ποὺ τοὺς ἐπιτρέπουν νὰ ἀνταλλάσσουν πληροφορίες καὶ ἰδέες μὲ ἀποτέλεσμα τὴν αὔξηση τῆς συμμετοχῆς καὶ τῆς ἐπικοινωνίας καθὼς καὶ τὴ βελτίωση τοῦ γνωστικοῦ ἐπιπέδου τοῦ κάθε μέλους. Ἡ κλιμάκωση (scaling, π.χ. ἀπὸ τὸ ἐργαστήριο στὶς ἐπιχειρήσεις) αὐτῆς τῆς διαδικασίας ἀποτελεῖται ἀπὸ ἕνα περιβάλλον συνεργασίας καὶ ἀνταγωνισμοῦ, ἑτερογενὲς ὡς πρὸς τὰ μέλη του καὶ παγκόσμιας ἐμβέλειας. Παράδειγμα ἐφαρμογῆς τῆς νέας διαδικασίας ἐκπαίδευσης εἶναι τὸ μάθημα σχεδιασμοῦ ποὺ διδάσκω στὸ University of Washington, ὅπου μιὰ ὁμάδα σπουδαστῶν, σὲ συνεργασία μὲ ἐπαγγελματίες μηχανικούς, κατάφερε μέσα σὲ ἕνα πολὺ μικρὸ χρονικὸ διάστημα νὰ κατασκευάσει ἕνα λουτρὸ ἀνακυκλούμενου ὕδατος ποὺ χρησιμοποιεῖται πλέον ἀπὸ τὴν ἀεροναυπηγικὴ βιομηχανία. Σὲ ἕνα συμπόσιο ποὺ ὀργάνωσα τὴν ἄνοιξη τοῦ 1999 μὲ θέμα τὴ συνεχιζόμενη ἐκπαίδευση ἔγινε σαφὲς ὅτι ἡ ἐπιτυχία τῆς ὁμάδας ὀφειλόταν στὴ διαδικασία ποὺ ἑστίαζε τ' ἀποτελέσματά της ἐξ ἴσου στὶς ἐπιχειρήσεις, στὴν ἐκπαίδευση, στὸ σχεδιασμὸ καὶ τὴν ἔρευνα (Business, Education, Design, Research).

Ὁ BEDR βασίσθηκε στὶς συνδυασμένες ἀρχὲς τῶν 5S (Set in place, Sort, Standardize, Sustain, Shine) καὶ τῆς θεωρίας τῶν 6 σίγμα. Μὲ βάση τοὺς ἀνθρώπους, τὸν ἐξοπλισμὸ καὶ τὰ ἐρευνητικὰ προγράμματα, τὸ Polymeric Composites Laboratory τοῦ University of Washington ἀπέδειξε μὲ ἐπιτυχία ὅτι καὶ οἱ δύο φιλοσοφίες μποροῦν νὰ ἐφαρμοστοῦν σὲ μὴ κερδοσκοπικοὺς ὀργανισμούς. Ἕνα ἀπὸ τὰ πιὸ σημαντικὰ στοιχεῖα τοῦ BEDR εἶναι ὅτι ἀποτελεῖται ἀπὸ ἕνα παγκόσμιο δίκτυο ὀργανισμῶν (κερδοσκοπικῶν καὶ μὴ) καὶ ἀνθρώπων, οἱ ὁποῖοι, συνδυασμένοι σὲ ὁμάδες, μποροῦν νὰ ἐπιτύχουν πολὺ περισσότερα ἀπὸ ὅ,τι θὰ μποροῦσε ξεχωριστὰ ὁ καθένας.

Θὰ πρέπει τέλος νὰ τονιστεῖ ἡ σημασία τῆς διαδικασίας στὶς σύγχρονες δραστηριότητες, ἡ ὁποία ἀνεξάρτητα ἀπὸ τὴ βιομηχανία ἀποτελεῖ βασικὸ στοιχεῖο ὅλων τῶν ὀργανισμῶν, σὲ συνδυασμὸ μὲ τὸν πελάτη καὶ τὸ προϊόν, καὶ θὰ πρέπει νὰ κατανοηθεῖ καὶ νὰ ἐξελιχθεῖ παράλληλα μὲ τὴν ὁμαδικὴ ἐργασία μέσα σὲ ἕνα περιβάλλον ποὺ ἑστιάζει τὶς προσπάθειές του στὶς ἐπιχειρήσεις, στὴν ἐκπαίδευση, στὸ σχεδιασμὸ καὶ στὴν ἔρευνα.

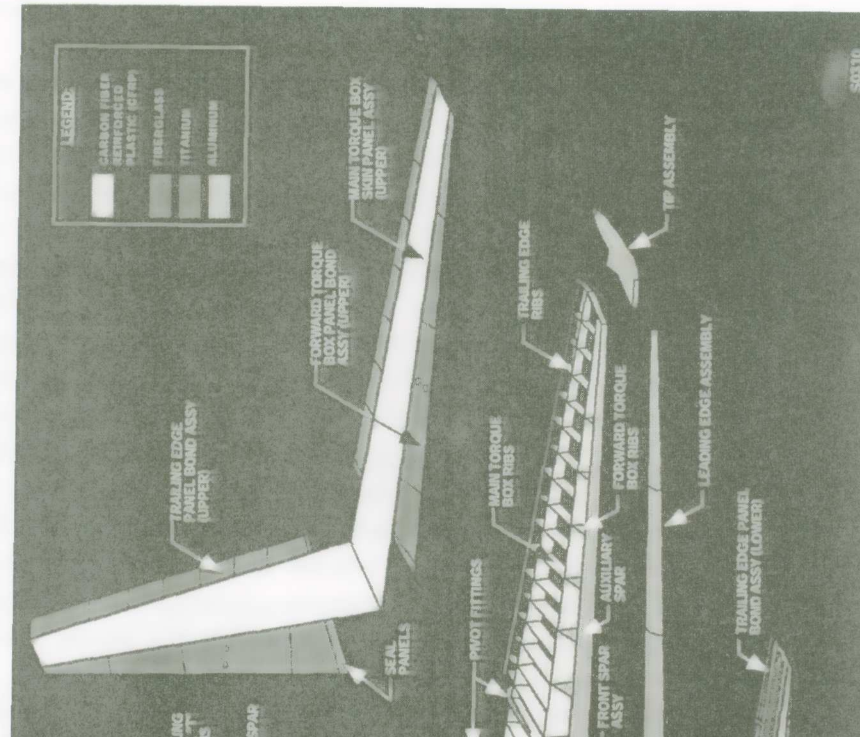

Figure 1: Composite applications in the wing of the Boeing 777.

Tell me ....I will forget;

Show me ....I will remember;

Involve me ....I will understand;

Figure 2: Confucian description of experiential learning.

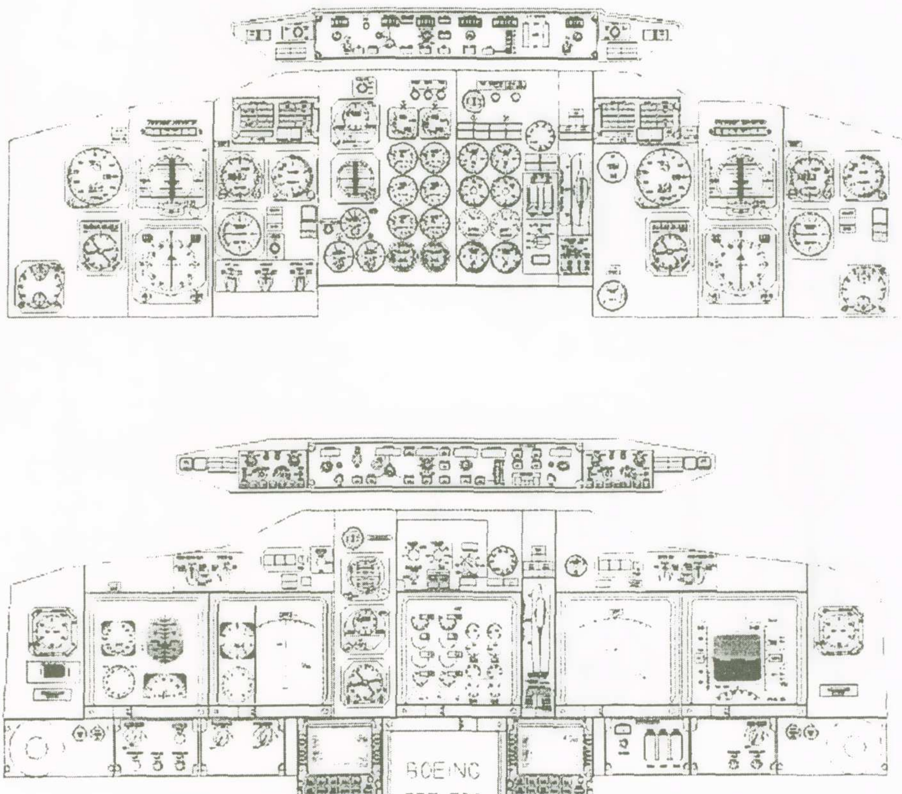

Figure 3: AutoCAD designs representing the evolution of the Boeing 737 cockpit.

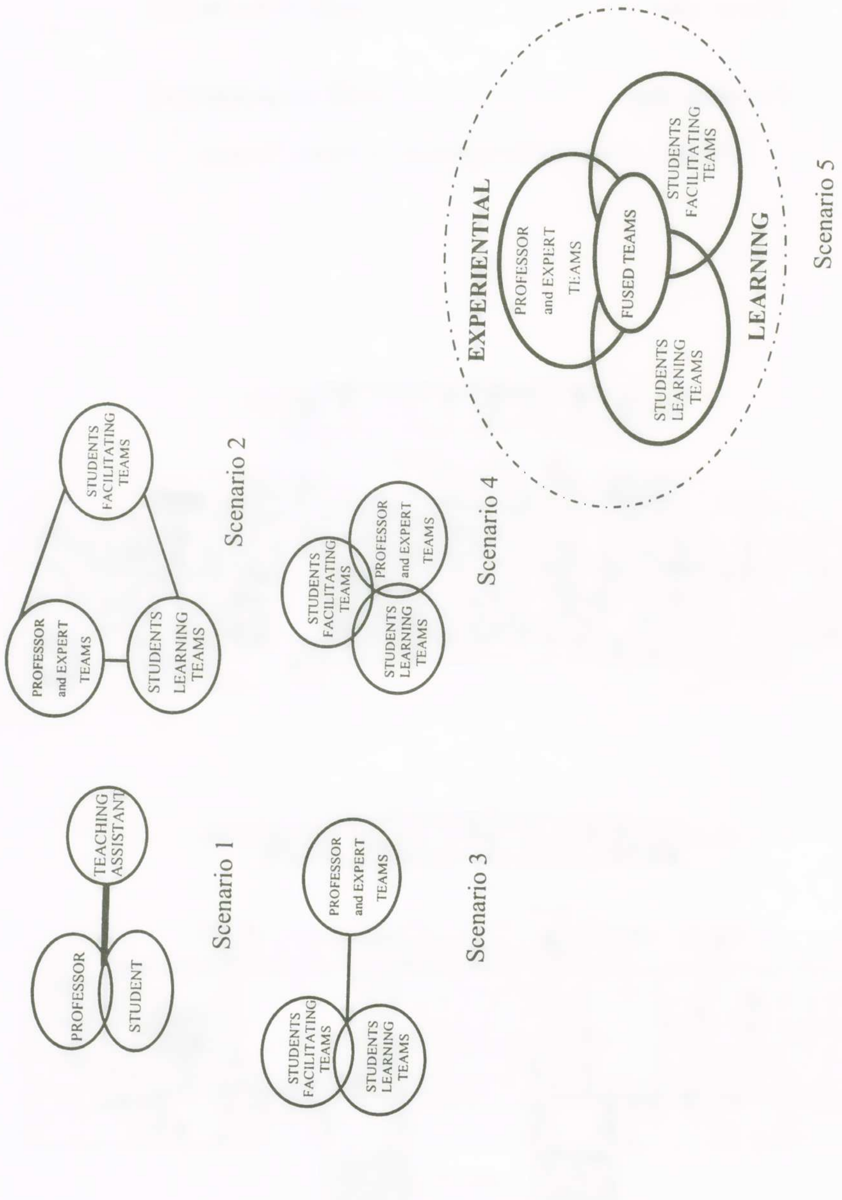

Figure 4: Various classroom teaching scenarios.

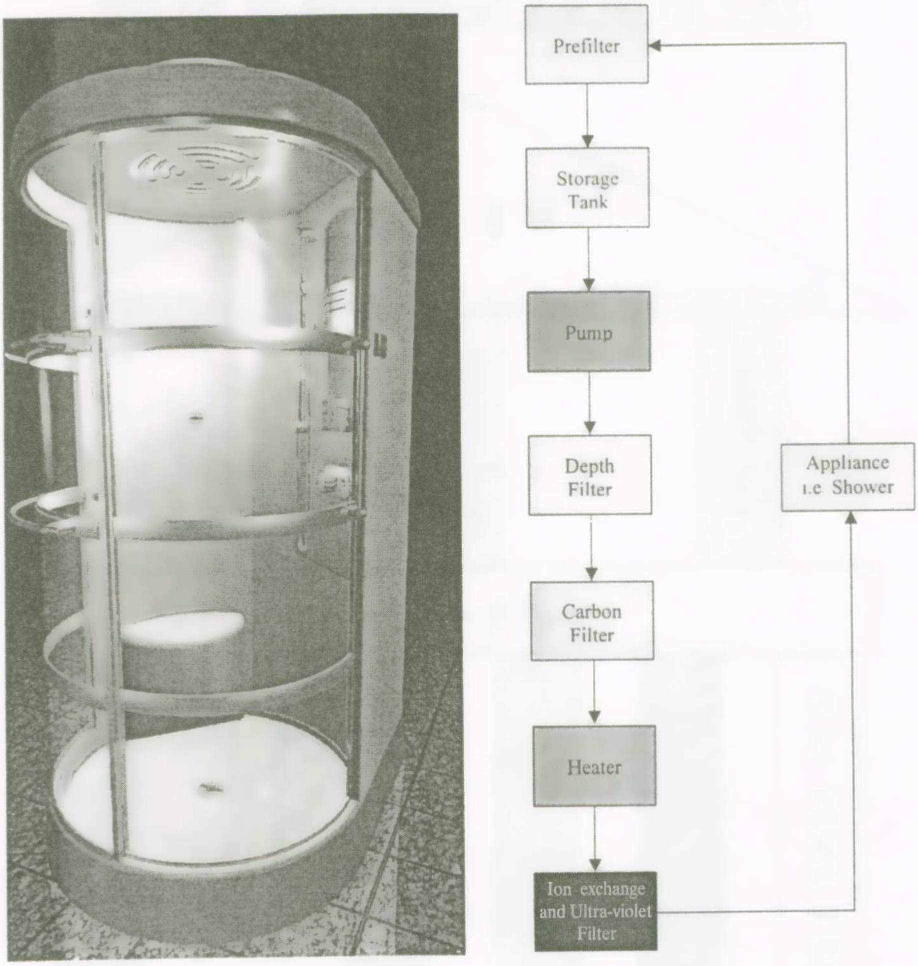

Figure 5: Recirculating shower prototype and schematic.

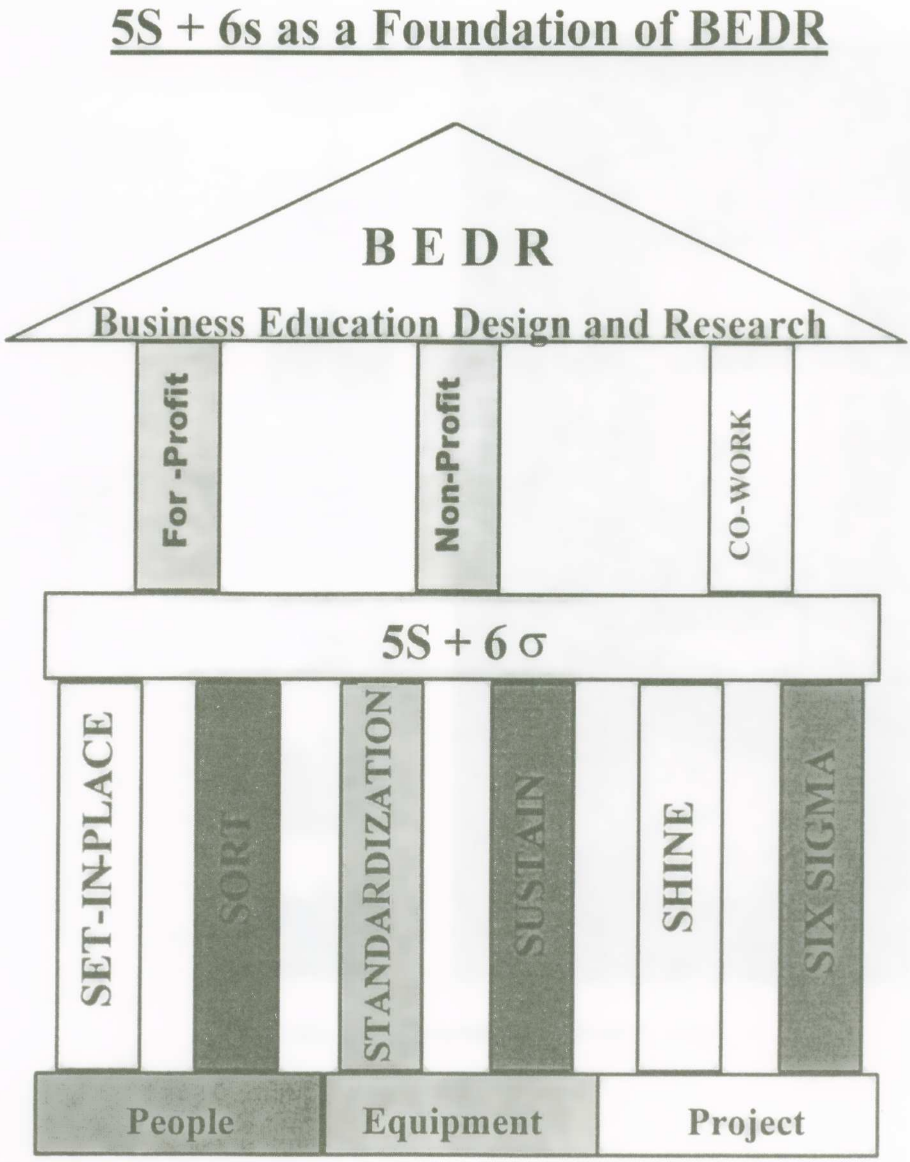

Figure 6: Temple schematic of the foundation of the Business Education Design and Research (BEDR) Organization.

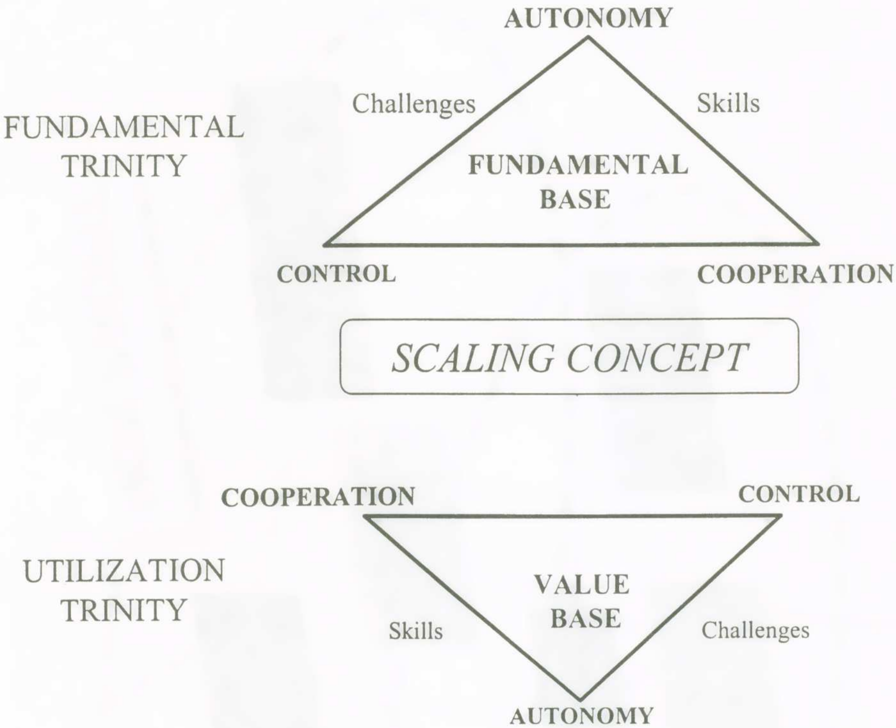

Figure 7: Generalized template for the double trinity methodology.

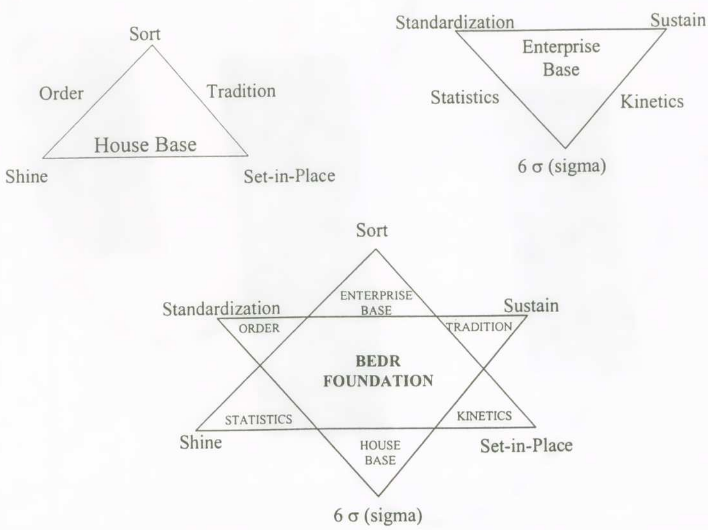

Figure 8: Double Trinity of $5S+6\sigma$

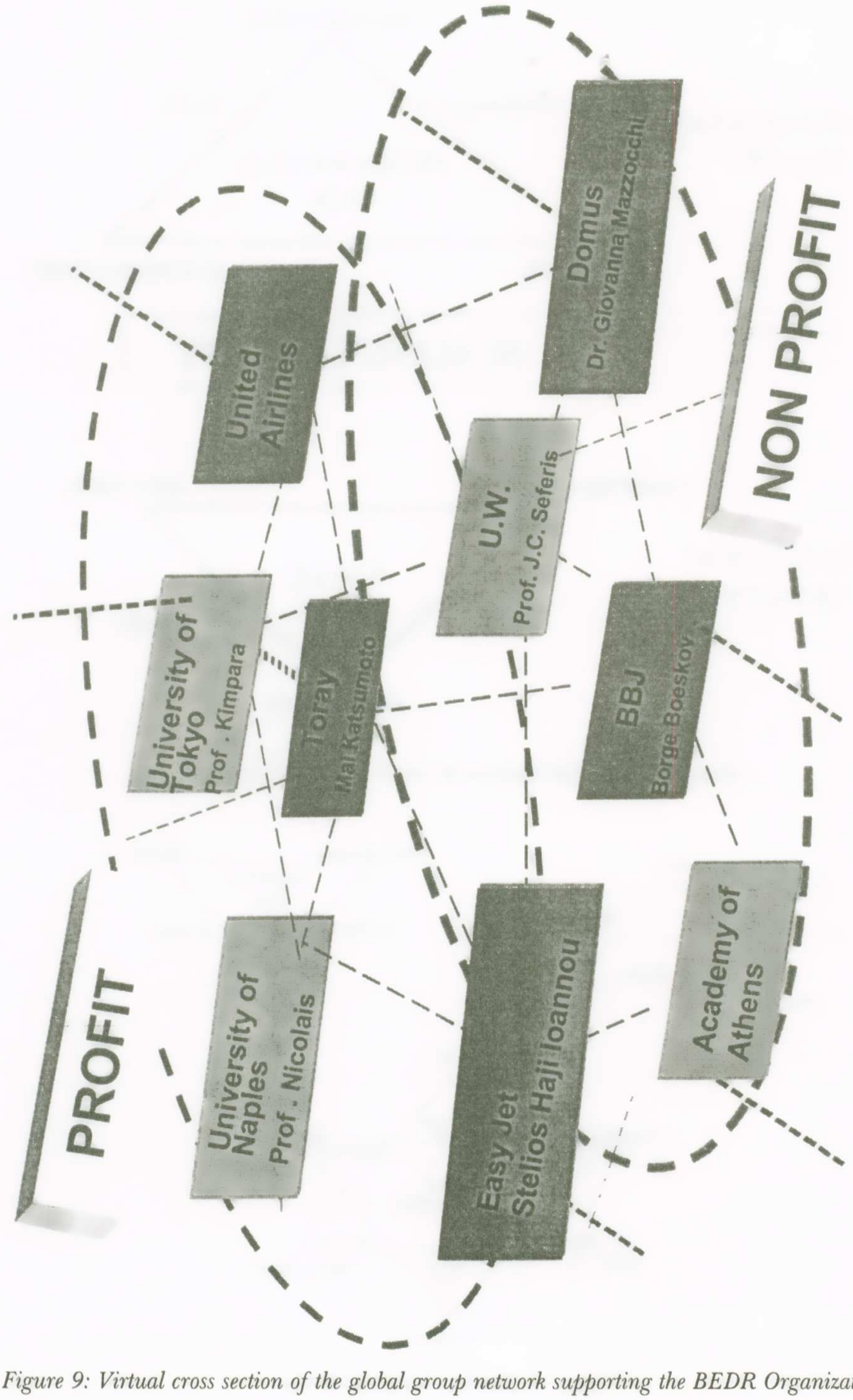

Figure 9: Virtual cross section of the global group network supporting the BEDR Organization.

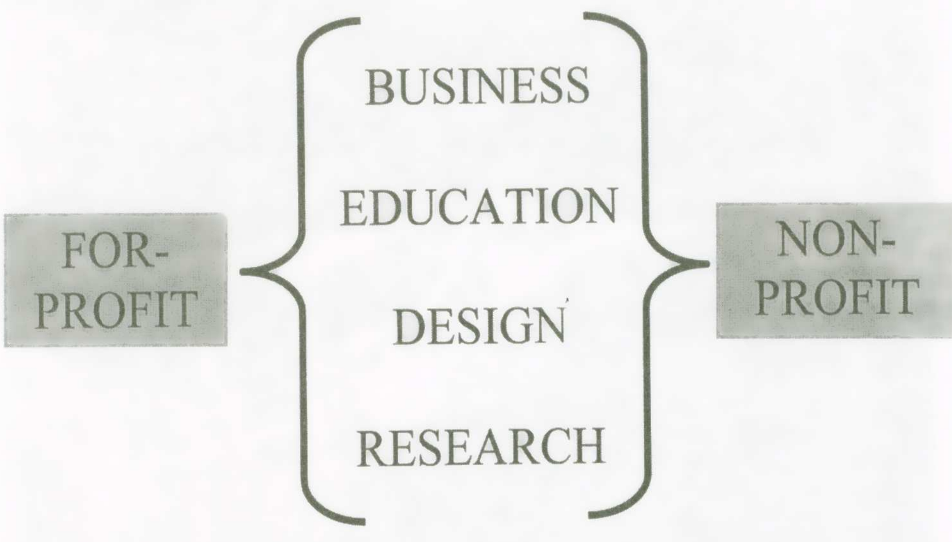

Figure 10: Schematic of for-profit and non-profit relationship in the BEDR Organization.

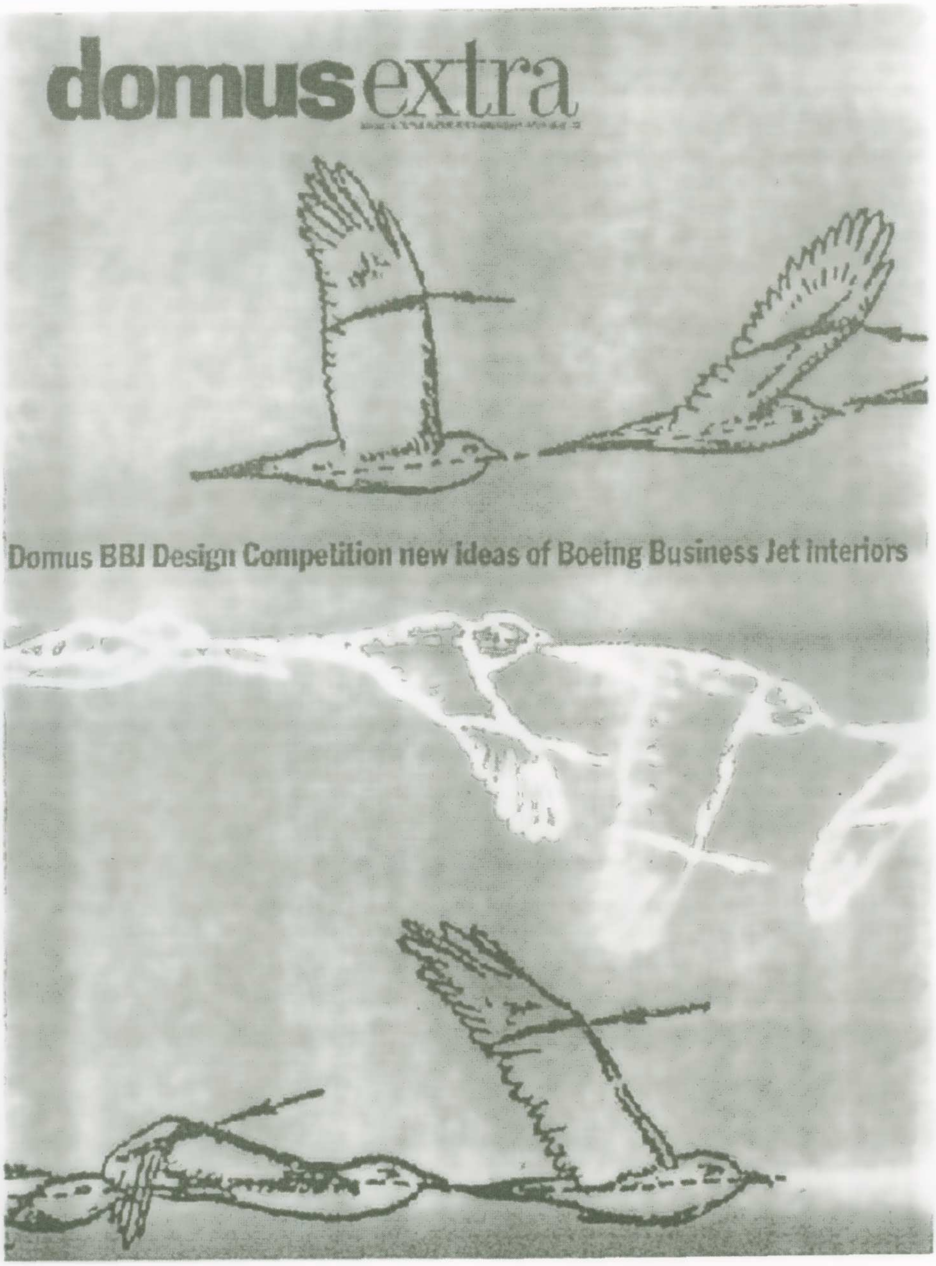

Figure 11: Coversheet from the winning announcements of the Domus BBJ Interior design competition.

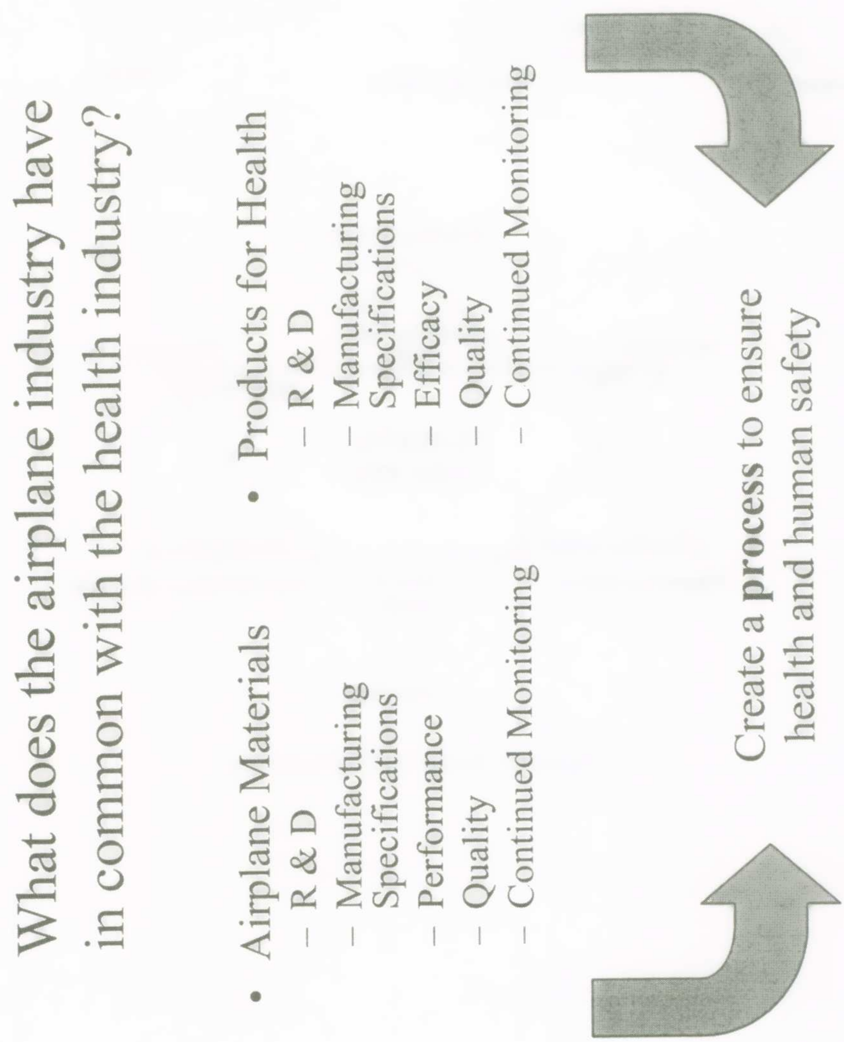

Figure 12: Similarities between the airline and medical fields.

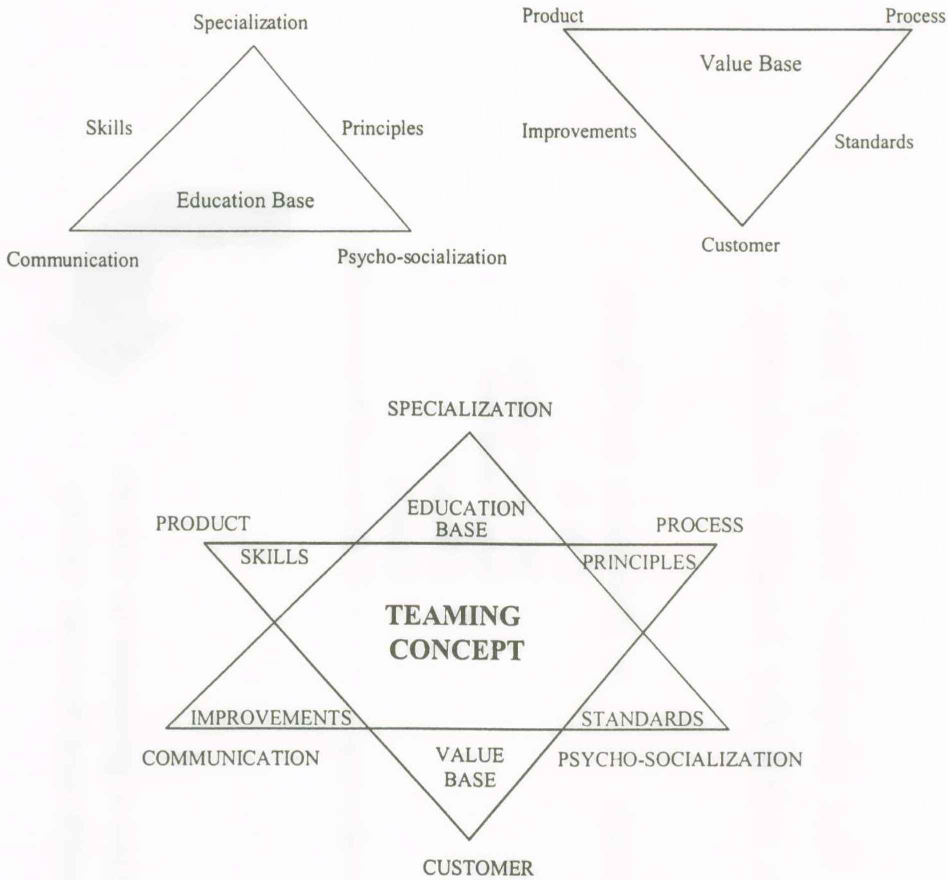

Figure 13: Double trinity of leadership.