Systems Thinking as a Major Skill of Business Students – A New Teaching Concept at the University of Zurich, Switzerland

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ABSTRACT

In our world of growing complexity, linear thinking and the belief that the whole is only the sum of its parts are evidently obsolete. Systems thinking, which promotes a holistic view of reality, is a situation-adequate handling of complex systems, and is therefore one of the most important skills of future executives in the business world. A new teaching concept was introduced one year ago by the Faculty of Business Administration at the University of Zurich, Switzerland. This concept was designed to help the students to develop abilities in thinking in models, operating complex systems and handling dynamic, non-linear situations. By use of a computer-simulated game the business students should gain knowledge about systemic realities and improve their complex-problem-solving skills. In the semester when the newly designed lecture started, the highly motivated class became aware of the problems in dealing with complexity. Documenting any significant improvements in our students' performance in playing the game was not possible, but we observed a change in their behaviour and ways of thinking in situations of complex problem-solving. Some necessary changes and adjustments in the teaching concept were made and the next class will be investigated in autumn 2003.

Keywords: business education, complex problem-solving, computer-simulated games, dynamic systems, systems thinking.

1. INTRODUCTION

Rapid, accelerating and unpredictable change is one of the major challenges today's business world has to face. Managers act in a transforming world of changing technologies, population and economic activity. The complexity of these systems is growing and the management's skills in dealing with this situation can be the crucial point for an organisation's success or failure. One of the major tasks of higher education in business administration is to prepare students – the future executives – for this challenging situation.

Today, we see ourselves confronted with the following dilemma: On the one hand, the technical and economic developments have led to an increase in complexity and interconnectedness. But on the other hand, this growing complexity brought with it a specialization of experts on certain fields, which is supported by our educational systems and the characteristics of modern science also specializing on a certain field of science and neglecting the general perspective and links between disciplines [1]. This has led to a so called reductionism: difficult, complex problems are separated into small parts that are easier to investigate and to handle. The system as a whole is ignored and the intervention to solve one problem may cause new problems, unknown side effects, further disturbances or may even leads into chaos. Unfortunately, we are not protected by the huge amount of information that we can access today. On the contrary: it creates a deceptive security [2].

Regrettably, this development is supported by many classical universities that teach business administration and emphasize on the classic functional business subjects of accounting, marketing, finance etc. Nowadays, the role of business schools in higher education should be a much broader one. Besides the professional competences that students gain, university teachers should also prepare their students for the business world by imparting social skills and teaching methodological subjects. Executives with profound skills in all three areas – professional, social and methodological – will make better and more successful decisions in the business world.

When the Chair of Performance Management was founded in 2001 at the Faculty of Business Administration at the University of Zurich, Switzerland, we decided to make the emphasis of our teaching program this last area – methodological skills - which is still often neglected but becomes more important in our complex world. We do not question the importance of the traditional subjects, but considering the short half-life of knowledge, we think that the traditional functional areas have to be supplemented by methodological subjects, first and foremost by systems thinking. World-wide, there are already a number of similar initiatives. In our research, we found some projects in the US that also emphasize teaching systems thinking to business students (for example at Harvard or at the MIT). But in Europe the number of universities that include systems thinking in their teaching curriculum is very low.

2. SYSTEMS THINKING

A system is a set of elements or objects together with relationships between these objects and between their attributes connected or related to each other and to their environment in such a manner as to form an entirety or whole [3]. The system with its elements possesses properties different from the collection of properties of the individual elements; the system is more than the sum of its parts [4]. The elements are connected together in an organized way and they are affected by being in the system. This is why especially for complex systems, i.e. systems with many elements that are connected, with dynamic, non-linear changes, time delays, feedbacks or late sequelae, a holistic view is important. That means that the interplay of individual elements cannot be reduced to the study of single parts [5].

The term "systems thinking" is widely used both in international and in German literature. A concise definition is hard to find, yet we prefer the view of the German cognitive psychologist Dietrich Dörner who reduces it to situation-adequate thinking in systemic, complex situations [6]. Richmond goes beyond this general definition and tries to distinguish systems thinking from the term system dynamics that was coined by Jay Forrester. He discusses seven basic systems thinking skills that are necessary for system dynamics modelling: dynamic thinking, closed-loop thinking, generic thinking, structural thinking, operational thinking, continuum thinking and scientific thinking [7]. Ossimitz specifies systems thinking by reducing Richmond´s listed skills to four characteristic dimensions [8] which are also important skills for managers and executives acting in the complex and dynamic business world:

Thinking in models
Thinking in models is the general ability for any systems thinking attempt. From a constructivist viewpoint, we can only think according to our pictures and views of the world, which are necessarily models of the world itself. Systems thinking requires the consciousness of the fact that we deal with models of reality and the ability of model-building, i.e. using appropriate tools to construct, describe and analyze models of systems, sub-systems, surrounding environments, etc.

Steering systems
This dimension brings in the practical steering of systems, and it comprises all system-oriented actions, finding out which elements of the system are subject to direct change and which elements only show a reactionist behaviour. A prominent field of science that mainly deals with this area is cybernetics which is about control and steering of complex systems by feedback mechanisms [9].
For the dimension of steering systems – and consequently for any cybernetic intervention in a system - , the following two abilities are necessary:

Thinking in loops
We often tend to think in simple cause-effect relationships or suppose linearity. But interrelated systems also have indirect effects that may lead to (positive or negative) feedback loops that are either reinforcing or balancing.

Dynamic thinking
When thinking in models, the time dimension must also be taken into account. Systems have a certain behaviour over time, time delays and oscillations may occur. An intervention in a certain system may only show effects after some time. If this fact is ignored, it might lead to overreaction and the system could get out of control.

Summarizing those aspects, we can say that systems thinking is a bundle of abilities used for dealing with complex, dynamic systems and applied according to the circumstances of the individual situation.

3. THE DIFFICULTIES OF COMPLEX PROBLEM SOLVING

Different studies, mainly done by psychologists, have shown that people have huge deficiencies in complex problem solving (a summary of some early studies was done by Joachim Funke in 1992 [10]). Since the 1970s computer-simulated scenarios have been investigated in lab-tests to identify the problems people have in dealing with complexity. These investigations simulated processes that occur when people handle complexity, like technical plants, and when human error or professional failure leads to enormous catastrophes, like in the Chernobyl case for instance.

We often ignore, or deny the complexity of the situations we deal with and reduce complex systems to cause-effect relationships. This leads to linear attempts of solutions for complex problems. Side-effects remain unnoticed and possible consequences are not checked before acting. When the interrelatedness of the elements remains unnoticed, a dynamic system can develop a momentum of its own, very often only after some time, as elements do not react immediately, but with some delay. This puts the actor under pressure, rash decisions might be made, and there is a tendency to over steer, which can lead the system into chaos, or - even worse – catastrophe. Another crucial factor in this context is the information overload, the huge amount of accessible information. We have problems in processing and evaluating it properly. Then we have to reduce it to the necessary parts and structure it, making it useful in the decision making process, but this is a difficult challenge.

In some investigations, business students also showed severe problems in dealing with complex systems (for example some empirical studies on stock-flow-thinking done by Sweeney and Sterman ("Bath-Tub-Dynamics") [11] or Kainz and Ossimitz [12]). They showed that the ability of students to discern between stocks and flows in practical situations is rather low. The performance of the business students distinguishing federal budgetary deficit (a net flow) and public debt (a stock) or the balance sheet (containing stocks) and the profit and loss account (containing flows) was approximately the same as if they had flipped a coin for each answer.

4. DEVELOPING SYSTEMS THINKING SKILLS

Having pointed out the importance of system dynamics and systems thinking for future executives, as well as the deficiencies people have in these disciplines, the next question to pose is how systems thinking skills can be developed.

There are things that people seldom, if ever, learn to do unless they are given explicit instructions in how to do them. Thinking and problem-solving are not of this kind. Everyone thinks, and everyone engages in problem-solving, with or without the benefit of formal education. But this does not mean that we do these things well [13]. The opposite is the case, especially in complex situations when systems thinking is required we tend to fail because of the deficiencies mentioned in chapter 3.

It is generally known that the most effective learning comes from direct, personal experience. We learn through trial and error: we take an action, see its consequences and then take a new, different action. But it is very difficult to learn systems thinking in the real world. The mistakes made only become evident with a certain delay in time and side effects might remain totally unnoticed. The primary consequences of our actions often are in the distant future or in a distant part of the larger system within which we operate. We do not learn from our action if the consequences lie outside of our learning horizon, the breadth of vision in time and space within which we assess our performance. When the consequences are beyond our learning horizon, it becomes impossible to learn from direct experience [14]. These incomplete learning cycles are also the core learning dilemma confronting organizations: it is known that we learn best from experience, but the executives making decisions in organizations often never directly experience the consequences of their actions. Important decisions often have system wide consequences that stretch over years or decades. This is another reason why systemic thinking is crucial for executives, but – as we see from above – it is not likely that we learn this style of thinking from reality.

Therefore, a very common method to investigate and teach systemic thinking and action is the use of computer-simulated games. Simulation is the process of designing a model of an existing system and experimenting with this model, in order to understand the behaviour of the whole system or to evaluate strategies to operate it. When playing those computer-simulated games, the actors learn "by doing", without being exposed to the dangers that the system would show in reality. Another advantage is that the simulation runs fast, a number of years can be simulated in a short period of time, so consequences stretching over several years are also evident. Through the mistakes they make and the consequences that these mistakes have, the actors gain sensitivity for the system and are able to learn how to handle the system as a whole.

5. THE FIRST ATTEMPT OF THE NEW TEACHING CONCEPT

An appropriate computer-simulated game

The method of teaching systems thinking by computer-simulated games is also the method we chose when we decided on teaching systems thinking in our performance management class in the fall/winter semester 2002. The software we used is a game developed by a research group of German psychologists. The program simulates the situation of a tribe of nomads living in the Sahara desert. The players act as development aid workers and have the possibility of direct interaction with the system. They have dictatorial authorities and full power to intervene in the economic and social situation of the tribe. A single simulation represents a time period of 21 years. After each year the players get feedback about the consequences of the interventions they planned a year before. In most of the years, new measures can be set or the intensity level of the existing measures can be changed. Only after 5, 10 and 15 years, the interventions set cannot be changed for a period of 2, 3 and 5 years, which has to be considered when taking the measures.

The computer-simulated game that was used shows the needed characteristics of a complex, dynamic system:

- There is a lot of information that has to be structured and processed.
- Not all of the information needed to make reasonable, successful decisions is evident; it has to be procured actively by the player from the instructor or from the program itself.
- There is a huge number of elements in the system and they are connected with each other. These interconnections have to be found out in order to be able to operate the system according to the dependency structures. But this is difficult and complicated as the reactions might only occur with a certain delay in time or at a distant part of the system.
- The players have several conflicting goals to be met: they should try to improve the health status of the members of the tribe, bring their economic situation to a sustainable and sound state and consider the environmental conditions.

Our experimental design

To investigate our students' skills in complex problem-solving we used a pretest-posttest-design. In teams of two people, the 23 students that took the lecture had two four-hour game sessions, one of them at the very beginning of the semester, the other one at the end. In the remaining sessions, the students had a weekly theoretical lecture on systems thinking with the following topics:

- processes of problem identification
- problems of linear thinking, thinking in contexts
- identification and description of complex systems
- hard and soft factors
- steering systems
- applications in a business context
- successful management from a systemic perspective

With the pretest-posttest-design, we hoped to make a comparison between the two game sessions, investigating whether the students improved their problem-solving skills by our theoretical lecture, or not.

In order to enable us to understand the students' decisions and to investigate whether there was an improvement in their systemic skills or not, we had them document all the measures they took year by year together with some key indicators for the situation of the tribe of nomads. In addition, we wanted to gain some information about the emotional perspective of handling a complex, dynamic system, so we had our students answer the following questions:

At the first game session at the beginning of the semester:

How do you estimate your ability to control the system? In which areas have things developed different from your expectations? According to your opinion, if things have developed otherwise than expected what are the causes? How secure do you feel in operating the system?

At the second game session at the end of the semester:

How do you estimate your ability to control the system? In which areas have things developed different from your expectations? According to your opinion, if things have developed otherwise than expected what are the causes? How secure do you feel in operating the system this time? Did you have the impression to control the system better through the acquired theoretical knowledge?

The results

Comparing the key indicators of the social and economic situation in the system between the first and the second game session, there was no significant improvement. What we observed at the second game session at the end of the semester was that the students had a different approach in how to operate the system. In the first game session the majority of the students concentrated on taking measures in those areas that showed the worst performance without questioning what these bad results might be due to. They showed the known deficiencies that people usually have in complex problem-solving and in operating a complex, dynamic system. In the second game session we observed a more well-planned and farsighted behaviour of our students. Before taking actions a lot of them tried to find out the key elements of the system and how they are connected. Although the results that were documented were not significantly better when they played for the second time, 33% of the students said that they estimated their abilities to control the system to be better than in the first session. 42% said that the knowledge they gained during the theoretical lecture had helped them and that they felt more secure when operating the system the second time. Evaluating these observations, we can say that our students improved their abilities in thinking in models. Since the computer-simulated game that was used is so complex, we can only assume that some of the abilities to steer a complex, dynamic system improved as well, but we do not know which of them.

6. LESSONS LEARNED

The study allowed us to make a statement about the different (non)existing skills in managing a complex system without being aware of the problems that might occur. Comparing the results of some key indicators of the system of the first game session with the ones of the second game-session, we could not observe an improvement of our students' performance. But what we did observe was a change in the way of thinking and of handling the complex system. This is due to several reasons which we found out and which led us to change our teaching concept. The new ideas will be implemented in our next class which will be held in the fall/winter term 2003.

What we can surely take from this first experiment with our students is that the motivation on both sides, students and lecturers, was extraordinarily high during the whole lecture. Using the computer-simulated game as a complex system that the students have to deal with is an appropriate tool for a class in university education, especially in business administration, but also in other disciplines. We think that a lecture like this can be taught at all levels, the only restriction is the class size because of the infrastructure needed. The fact that we had our students play the computer-simulated game in teams of two students proved to be a very good method. They had lively discussions in the teams which again fostered the motivation of all participants.

The computer-simulated game that we used for this lecture was a very comprehensive complex system showing all the possible difficulties that a complex system can have. To be able to observe, in which of the dimensions that systems thinking has and that have been mentioned in chapter 2, the students improved their skills, we will for our next class additionally use another computer simulation that extracts single categories of problems and classifies them according to difficulty levels. We will also try to have more interconnections between the game and our theoretical lectures, so that the problems based on the computer simulation will be present during the whole term and theory will be explained with examples taken from the game.

7. CONCLUSIONS

Our students have definitely gained a higher awareness of the inadequacy of our conventional ways of thinking in this rapidly changing world. We are convinced that our teaching concept of the performance management class is a promising project - although there are still improvements to make - and that teaching systems thinking is important, not only for business students, but for all disciplines. The half-life of knowledge is getting shorter and modern science shows the tendency of reductionism and specialisation. Teaching systems thinking is an appropriate answer to this trend. We are looking forward to the next highly-motivated class that we will do this investigation with.

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