Can We Train Management Students to be Systems Thinkers- Additional Results

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***Abstract*-- Systems-thinking, a holistic approach that puts the study of wholes before that of parts, is an efficient way of dealing with real-world situations. By emphasizing the interrelationships between the system's components rather than the components themselves, systems thinking allows us to increase our personal and professional effectiveness, and transform our organizations. Specifically, systems thinkers can conceptually analyze the system without knowing all the details, recognizing the forest through the trees. They can see beyond the surface to the deeper patterns that are responsible for creating behavior [23].**

The current study deals with the development of systems thinking among students and graduates of technology management. The goals of the study are to identify the factors that influence the development of systems thinking and to find ways to encourage this development [17]. We used a variety of research tools: A questionnaire for assessing the capacity for systems thinking, The Myers-Briggs Type Indicator (MBTI) personality type test and supervisor evaluations.

In conclusion, the current study findings show that graduates with certain personality traits can gradually acquire or improve their capacity for systems thinking by receiving appropriate training and through a wide range of work experience, and by holding different job positions over time. Having a broad range of professional experience and holding different job positions can help graduates gain knowledge and become familiar with diverse systems and technologies.

I. INTRODUCTION

The method by which a complex problem is broken down into constituent elements allegedly facilitates the handling of complex assignments and questions; when engaging in this sort of breakdown, we often lose the perception of the larger whole that the problem involves. "Systems thinking," according to Senge [18] is a discipline for seeing wholes. It is a framework for seeing interrelationships and repeated events rather than things, for seeing patterns of change rather than static 'snapshots'. It is a set of general principles, specific tools and techniques that have been developed in recent years .Systems thinking seeks to discover the "constructs" underlying complex problems and to discern potential changes that might cause significant improvement with a minimum of effort (the principle of leverage). Systems thinking offers us a language that expands, changes, and reshapes our ordinary way of thinking in regard to complex issues.

There is no doubt that students and graduates of technology management will need systems thinking in their professional career. It will help them to see and understand multi-disciplinarian systems even without being deeply familiar with all the parts.

II. LITERATURE REVIEW

The systems approach is characterized by its focus on the relationship between different elements of the system; it emphasizes the interaction between these elements no less than the special properties of the system components themselves.

The systems thinking literature is extremely diverse and deals mainly with economics, social systems, analysis of complex organizations [21], [19], [15], [10], [8], [18] curriculum design [3], social work, psychology, addiction therapy, the human body as a system, the family as a system, health, businesses, the banking system, human interrelationships, the world situation, quality of the environment [16], instruction of groups and teams [14], [22], scientific and technological education [1], decision making [6] and project management [12].

The research literature shows different evidence of efforts to develop systems thinking through task-oriented software, group dynamics, education, and training [2], [9]. All of these attempts have shown that it is possible to acquire systems thinking in a variety of ways; it was also found that success in this process is of great importance to teachers/instructors.

According to Kordova and Frank's study [11], performing a capstone project, by engineering students, contributed towards the actual creation of systems thinking among the learners. An interesting finding was that lower levels of systems thinking were found among students with high mathematical skills. This result may be explained by the fact that the noticing of small details among the students with strong math skills hinders them from seeing the big picture.

Students and graduates with high systems thinking will be able to analyze customers' need and will be more capable of facing multi-disciplinarian problems in the business world.

Some authors refer to systems thinking as an innate ability. For instance, Hitchins [7] states that the human brain has the ability to see similarities of patterns between disparate sets of information, which presumably emanate from its drive to reduce perceived entropy. He also implies that some people are gifted in this respect. However, Frank [4] and Davidz & Nightingale [2] concluded that this ability is most likely a combination of innate talent and acquired experience.

III. RESEARCH OBJECTIVES

The current study examined the factors that might improve systems thinking among students and graduates of

management of technology. The main questions were as follows:

1. To what extent is it possible to train students and graduates for a systems job position?
2. To what extent is there a connection between the tendency towards systems thinking and subjects' personality traits?
3. To what extent is there a correlation between the capacity of systems thinking and supervisor evaluation?

IV. METHODOLOGY

A. *The Population*

The study population included two groups:

- The first group included 55 second degree students from management and technology faculty.
- The second group included 38 graduates who involved in development projects, at three companies. All the companies develop integrated systems for defense and homeland security applications.

B. *The Tools*

The first tool was a questionnaire for assessing the Capacity for Engineering Systems Thinking (CEST). The questionnaire was developed by Frank [5] and in its origin- was a tool for assessing the interest for systems engineering positions. The basic assumption of the questionnaire is that the capacity for engineering systems thinking can be distinguished among people. In other words, this capacity characterizes the individual and can be evaluated and predicted.

The questionnaire was distributed in the first group, before and after different graduate courses.

The items in the questionnaire deal with preferences, specifically likes and dislikes regarding a diverse group of activities, jobs, professions or personality types.

The tool is comprised of 40 pairs of statements. For each pair, the examinee has to choose between the two statements according to his/her preference. The subject checks answer "A" if he/she prefers the first statement or answer "B" if he/she prefers the second statement.

Here are two example items based on the characteristic 'seeing the whole':

Item No. 3

A. When I take care of a product, it is important for me to see how it functions as a part of the system.
B. When I take care of a product, it is important for me to concentrate on this product, assuming that other engineers will take care of the other parts of the system.

Item No. 14

A. I don't like to be involved with details; I prefer to deal with the system's aspects.
B. In areas in which I'm involved, I like to understand all the details.

In the second group, the subjects completed Frank's questionnaire [5] and also completed the Myers-Briggs Type Indicator (MBTI) personality type test [20].

In addition, supervisor evaluations were also conducted regarding these subjects' systems thinking capabilities. The MBTI personality type test is a method that evaluates personality type using a psychometric questionnaire. The goal of the test is to help people identify their dominant preferences, tendencies, and personality traits. According to the questionnaire, people have four psychological functions through which they experience the world: Energy (Extraversion versus Introversion), Information (Sensing versus Intuition), Decisions (Thinking versus Feeling) and Lifestyle (Judging versus Perceiving). For each, one of the four functions is dominant most of the time. The result of this questionnaire is one of the 16 character archetypes as shown in Figure 1.

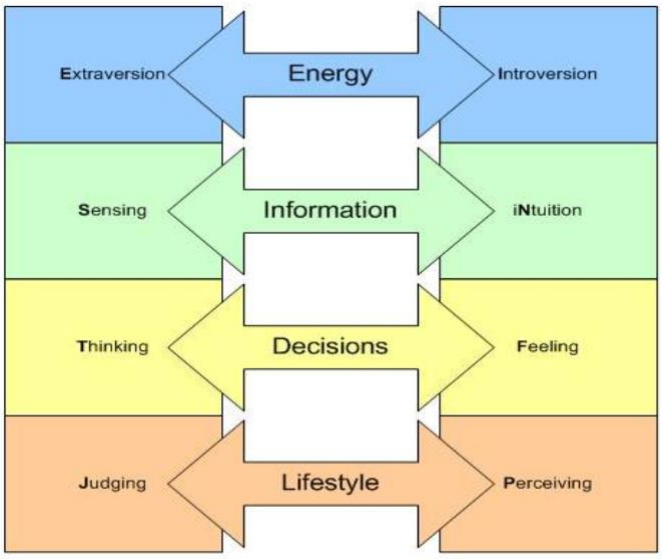

Figure 1: MBTI character archetypes

The current study examined the connection between the dominant personality traits (according to the MBTI research tool) and the subjects' systems thinking and field of expertise.

We examined different kind of reliability and validity of Frank questionnaire. Two types of reliability were calculated- inter-judges reliability and Alpha coefficient reliability. Four types of validity were presented- content validity, concurrent validity, contrasted group validity and construct validity.

V. RESULTS

Table 1 presents the paired samples T-Test. The test compares the average score of graduate management and technology students before and after engineering design course. The course lasted two semesters and the subjects completed Frank questionnaire at three stages: At the beginning of the course, at the end of first semester and at the end of the second semester.

TABLE 1: PAIRED SAMPLES TEST

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	total_pre - total_post1	-2.63889	6.50069	1.53223	-5.87161	.59383	-1.722	17	.103
Pair 2	total_post1 - total_post2	18.12500	32.75583	7.32443	2.79480	33.45520	2.475	19	.023
Pair 3	total_pre - total_post2	18.19444	34.45805	8.12184	1.05886	35.33003	2.240	17	.039

TABLE 2: CORRELATIONS

		SYS total	SED (System Engineering Desire)	Rating	Years in system projects
SYS total	Pearson Correlation	1	.763**	.855**	-.135
	Sig. (2-tailed)		.000	.000	.420
	N	38	38	38	38
SED (System Engineering Desire)	Pearson Correlation	.763**	1	.787**	-.138
	Sig. (2-tailed)	.000		.000	.409
	N	38	38	38	38
Rating	Pearson Correlation	.855**	.787**	1	-.169
	Sig. (2-tailed)	.000	.000		.311
	N	38	38	38	38
Years in system projects	Pearson Correlation	-.135	-.138	-.169	1
	Sig. (2-tailed)	.420	.409	.311	
	N	38	38	38	38

**. Correlation is significant at the 0.01 level (2-tailed).

According to Table 1 there wasn't found a significant difference between the average score of the subjects at the beginning of the course and at the end of the first semester (Sig=0.103). There was a significant difference between the average score of the subjects and the end of the first semester and at the end of the course (Sig= 0.023). A significant difference was also found between the average score of the subjects at the beginning and at the end of the course (Sig=0.039).

Table 2 showed that there is a correlation between supervisors' ranking in relation to subjects' systems thinking capabilities and the average score they received on Frank's questionnaire (Sig=0.000 ,r=0.855).

In addition, while they were filling out the questionnaire, the subjects themselves were asked to evaluate their desire to engage in systems-related projects; a significant correlation was found between this evaluation and the results of Frank' questionnaire (Sig=0.000 ,r=0.763).

In contrast to these findings, no correlation was found between the capacity for engineering systems thinking and number of years' employment experience.

The current study's findings are in line with those of previous studies, according to which any individual – who can report about himself or others – that they notice details or immediately see the big picture.

The fact that it is often possible to distinguish a capacity for engineering systems thinking, even after only a few years of work experience, proves that apparently there are additional factors that strengthen systems thinking acquisition. Among these factors, there is also the notion of innate potential - which seems to be an inseparable part of those candidates who received a high systems thinking score, even though they had little work experience (in years).

In addition to all of the above-mentioned findings, the subjects were divided into personality groups according to the MBTI questionnaire.

The study findings also support Meade's results [13] according to which 57.9% of the respondents belong to the STJ (Sensing, Thinking, Judging) group. The character archetypes distribution is shown in Table 3 and Figure 1. This finding emphasizes the fact that a large percentage of the subjects belong to particular personality groups with unique traits.

TABLE 3: RESULTS OF MBTI QUESTIONNAIRE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	ENFP	2	5.3	5.3	5.3
	ENTJ	6	15.8	15.8	21.1
	ENTP	1	2.6	2.6	23.7
	ESFJ	4	10.5	10.5	34.2
	ESTJ	16	42.1	42.1	76.3
	INTJ	2	5.3	5.3	81.6
	ISTJ	6	15.8	15.8	97.4
	ISTP	1	2.6	2.6	100.0
	Total	38	100.0	100.0	

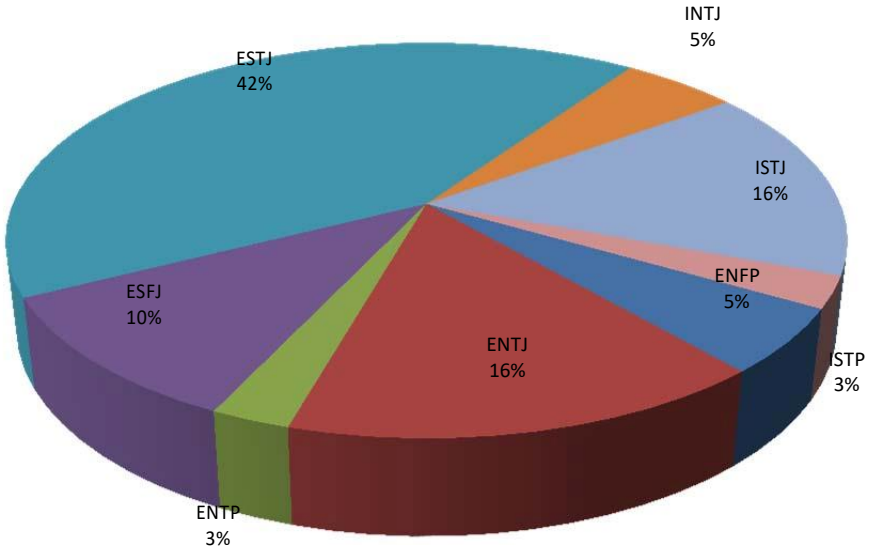

Figure 2: Character archetypes distribution according to MBTI Questionnaire

VI. CONCLUSIONS

According to the findings of this study systems thinking is a process that develops gradually.

Systems thinking can be acquired through active study in a formal teaching or a training framework. The curriculum requires to develop systems vision includes workshops, practice and preform systems projects in teams.

Systems thinking should be taught within the context of the learners' studies, and not as isolated knowledge.

Moreover, systems thinking can be also acquired through experience in different job positions, which enables learning about different aspects of the system.

A high level of systems thinking also relies on personality traits. These traits may be identified in a number of ways:

- A questionnaire for assessing the capacity of systems thinking [5].
- MBTI – Myers-Briggs Type Indicator – Personality Type test [20].
- Testimonies of the employees themselves and their employers.

These findings allow for:

1. The identification of people who can develop a high level of systems thinking – according to the questionnaire's results and also through knowledge gleaned from employers and from the employees themselves.
2. The contribution of the development of systems thinking: to hasten its development – through an appropriate curriculum, and by providing the opportunity to acquire meaningful experience.

In conclusion, the current study findings show that subjects with certain personality traits can gradually acquire or improve their capacity for systems thinking by receiving appropriate training and through a broad range of work experience, and by holding different job positions over time. Having a broad range of work experience and holding different job positions can help graduates gain knowledge and become familiar with diverse systems and technologies. By experiencing various fields of expertise, graduates can learn from the experience of others, working with other peoples who have systems thinking skills, and observe how they deal with issues that require this type of thinking.

With the help of effective management and a manager who knows his subordinates well, it is possible to assign graduates to appropriate tasks, in accordance with their personality traits, thus allowing them to work in jobs that require systems thinking and relate to the big picture.

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