Technology Management Education for Improving Systems Thinking

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Abstract--Systems thinking **is a concept of thinking about an issue as a whole, emphasizing the interrelationships among its components rather than the components themselves. The main goal of this study is to examine whether the ability for systems thinking can be developed through experience, education, courses, and training.**

We present graduate and undergraduate courses in management of engineering and technology, aimed at developing a capacity for engineering systems thinking (CEST) in students. The undergraduate course is based on executing projects in teams. The graduate course is based on systems engineering principles. At the start and at the end of the courses, CEST is evaluated by addressing and measuring four components: cognitive characteristics, abilities, personal traits, and knowledge. The data collected in the current study was used to analyze the four above-mentioned components of CEST.

The study findings allow us to conclude that systems thinking can develop by participation in courses and other appropriate educational programs. Better understanding of the ways in which system thinking is developed can provide a better foundation for systems thinking educational programs.

I. BACKGROUND

Today's business environment is the outcome of technological, social, and economic changes. This environment is characterized by a globalized world economy, fierce inter-organizational competition, the use of innovative management approaches, the availability of information and knowledge accompanied by rapid and inexpensive media, and advanced information systems. Over recent years, technology has become central and highly influential to our lifestyle in the developed world. As a result, graduates of technology management require better training and preparation than in the past. They must be proficient in the many new and existing technologies and capable of handling complex information systems.

Management of engineering and technology studies include specialized subjects in operation and production management. These studies expose learners to different approaches and techniques that aid the organizational decision-making process, as well as teach basic subjects such as statistics, marketing principles, and economics. The combination of basic subjects with specialized subjects provides learners with a holistic vision—necessary to their professional performance after completing their studies. Studying and becoming familiar with an organization as a single system comprised of many components is intended to enrich a student's understanding and ability to implement methods for improving the organization and making it more efficient.

The study population included two different groups: senior technology management students who were registered for a "capstone project" course and 12th-grade high school students who prepared a "final project" as part of their final examinations in industrial engineering and management. In this project, the students need to implement significant skills in industrial engineering and management such as processes planning, quality engineering, operation, and production management. To perform a project in management of engineering and technology, students must implement what they have learned in many courses, and they must cope with interdisciplinary problems in management of engineering and technology.

The results and findings of the final project are then presented to the organization's management to aid the decision-making process, leading, in turn, to improved organizational performance. Project performance includes the following: students are required to identify an organization, present a process they want to examine, analyze the organization's performance, and recommend ways to improve processes in the organization, using management of engineering and technology tools. Each project must be performed in a specific organization to provide a practical dimension to the student's work.

Research Objective

The research objectives are:

1. To examine how the performance of a project contributes to the development of students' capacity for engineering systems thinking.
2. To examine the processes by which the capacity for engineering systems thinking is acquired while participating in a course based on holistic principles.

II. LITERATURE REVIEW

In the literature review, we present the project-based learning (PBL) approach. This approach is used in both the high school curriculum and the academic course. We also define the concept of *systems engineering thinking* and discuss the dilemma of whether we can develop this capacity.

A. Project-Based Learning (PBL)

In many areas requiring high-level training, such as engineering, medicine, science, and management of technology, a PBL approach is often developed. PBL is an integrative learning environment requiring learners to solve problems using high-level thinking. In this learning environment, students examine authentic problems from the real world.

Many researchers have cited the advantages of PBL. For example [3] and [10] state the following advantages: the possibility of gaining considerable multidisciplinary knowledge, active learning, significant and authentic learning, developing thinking skills, synthesizing (and not just analyzing), developing teamwork skills, gaining experience in the design process, gaining experience in the "top down" approach, becoming familiar with the importance of optimal design, developing a capacity for engineering systems thinking, becoming familiar with the principles of project management, developing various study skills, and improving scholastic achievements. In the current study, we implement this approach in management of engineering and technology courses.

B. Systems Thinking

Systems thinking is a concept that reflects thinking about the issue as a whole, emphasizing the interrelationships among its components, rather than the components themselves. According to [22] Systems Thinking is the art and science of making reliable inferences about behavior by developing an increasingly deep understanding of underlying structure.

Reference [23] uses the paraphrase "forest thinking" to clarify the concept of systems thinking. According to [23], forest thinking involves a "view from 10,000 meters rather than focusing on local trees" and "considering how the system influences systems on the other side of the line and how these latter systems influence the former system."

Reference [21] emphasizes the importance of advancing systems thinking in organizations. Efforts to implement systems thinking need to be focused. He also mentions formal education as an important arena in which we can advance the cause of systems thinking. We need solutions (at all levels) that address similarities among disciplines, rather than differences. Part of the reason we so easily become "trapped in the specifics" is that we are conditioned via formal education to analyze, separate, and focus on the details of each part. Too little effort is spent in developing peoples' ability to see the generic—that which persists across disciplinary boundaries. Not enough time is devoted to exercising peoples' "intuition about the whole."

C. Systems Thinking as a Holistic Term

Systems thinking is a process of discovery and diagnosis—an inquiry into the governing process underlying the problems we face and the opportunities we have.

Systems thinking is a way of thinking about, and a language for describing and understanding, the forces and interrelationships that shape the behavior of systems [24].

Reference [24] describes systems thinking as:

- A discipline for seeing wholes.
- A framework for seeing interrelationships, for seeing patterns of change rather than static "snapshots."
- A set of general principles—distilled over the course of the 20th century, spanning fields as diverse as the physical and social sciences, engineering, and management.
- A specific set of tools and techniques.

According to [24] a good systems thinker, particularly in an organizational setting, is someone who can see four levels operating simultaneously: events, patterns of behavior, systems, and mental models. It is systems thinking that brings the disciplines of personal mastery, mental models, shared vision, and team learning all together.

References [24], [17], [20] and [28] claim that systemic thinkers are able to change their own mental models, control their way of thinking, and deal with the problem-solving process. They suggest that, within the system, cause and effect might not be closely related in time and space. Therefore, one of the mechanisms for using systems thinking in a problem-solving situation is based on the ability to enlarge a system's borders and expose its hidden dimensions. In organization systems, this dimension is expressed by social factors such as values, beliefs, and interests that lie under the surface. Moreover, to analyze the system's behavior within the time dimension, one should present backward (retrospection) and forward (prediction) thinking skills [1].

According to [6] there is a difference between systems thinking and other types of analytical thinking such as: looking outwards rather than inwards and focusing on functionality or what the system is supposed to do, rather than at the structure and how things work.

The Engineering Systems Division (ESD) Symposium committee [5] defines systems thinking as a holistic term. According to this definition, "Systems thinking is the ability to think about the system as a whole; focus, an ability to address the important systems level issues; emergence, recognition that there are latent properties in systems; and trade-offs, judgment and balance, which enable one to juggle all the various considerations and make a proper choice."

Reference [25] mentions systems thinking in the context of seeing the world as a complex system in which we understand that "you can't just do one thing" and that "everything is connected to everything else." The principles of systems thinking have evolved as a result of observing common holistic aspects of systems in diverse fields of endeavor. These principles are founded upon an understanding that there are common relationships between systems in nature and in and amongst man-made systems that are useful to understand and exploit [19].

D. Capacity for Engineering Systems Thinking (CEST)

Based on [23] term "forest thinking," [8] posits that forest thinking allows engineers and managers to distinguish between the major and minor, relevant and irrelevant dimensions of a given system or issue. Engineers with high CEST are able to simplify—to filter out redundant, unnecessary information and "noise" to clear up and understand the picture [8].

According to [12] engineering systems thinking is:

1. The ability to see the whole picture—the ability to perceive and understand the entire system conceptually and with respect to its performance, without understanding the system's details. This ability includes synergizing various components of the system, as well as the ability to predict all implications of change in the system and to propose solutions for system failures.
2. The ability to implement managerial considerations—the ability to understand and implement managerial considerations that include a comprehensive approach.
3. The ability to acquire and use interdisciplinary knowledge—the ability to cope simultaneously with diverse tasks and use interdisciplinary knowledge to develop an operational approach, to carry out a functional and architectural analysis, to compare systems, to apply the system planning constraints, to run simulations, and to solve optimization problems.
4. The ability to analyze needs and requirements—the ability to understand and analyze a costumer's needs, marketing requirements, and future technological developments.
5. To be a systems thinker—the ability to be curious, innovating, and self-learning, and to develop and ask relevant questions.

E. Systems Thinking Development

There is an ongoing argument in the literature about whether systems thinking ability is inherited (innate) or learned (acquired). For instance, [14] refers to systems thinking as an innate ability and states that the human brain has the ability to see pattern-based similarities among disparate sets of information that presumably emanate from its drive to reduce perceived entropy. He also implies that some people are gifted in this respect. On the other hand, [4] and [16] found that systems thinking may be developed through experience, job rotation, education, and training. Well designed and taught systems engineering courses may accelerate systems thinking development.

Reference [13] claims that learned systems thinking is possible, but innate systems thinkers are more creative. Systems thinkers always begin by framing a situation within a context. They can find parallels between different contexts and apply prior experiences to new and unfamiliar situations. Reference [27] claim that we must find opportunities for students to immediately apply what they learn in the classroom to real problems in industry. Practical interactions between ideas and experiences help engineering become real. Reference [1] presents a study of earth systems education that deals with the development of systems thinking skills at the junior high school level. The study [1] shows that, in spite of the minimal initial systems thinking abilities of the students, most of them made some meaningful progress in their systems thinking skills, and a third of them reached the highest level of systems thinking within the context of the hydro cycle.

Reference [7] points out the close relationship between the characteristics of systems thinking and other higher order thinking skills. Similarly, [2] argues that effective systems thinking requires good scientific reasoning skills, such as the ability to use a wide range of qualitative and quantitative data. These abilities are attributed to higher order thinking abilities.

Reference [29] demonstrates, by re-reading 120 journals of graduate students in a systems thinking course, that systems thinking can be taught, and that once students are introduced to the subject, they can link their decisions to consequences; they can see the delays in a system, refrain from blaming external "others," and figure out how they themselves contribute to the existence of an issue or problem.

To explore the question "How does systems thinking learning actually occur?" reference [18] observes and examines masters-level students who are introduced to systems thinking. He explores how interacting with systems thinking tools affects students in the process of collaboratively analyzing and modeling complex problems, and how cognitive and semiotic (i.e. the relation between signs and the things to which they refer) resources are used in this process. Reference [26] proposes the use of metaphors, both for teaching systems thinking and for clarifying other concepts of organizational theory in an introductory management course. Reference [15] examines the effects of utilizing systems modeling as a cognitive tool for enhancing systems thinking skills in a group of graduate students.

III. METHDOLOGY

The study subjects included:

- Forty-two (42) senior technology management students who were registered for the capstone project course in one of the country's academic institutes. The students were required to submit a capstone project during one full academic year in the area of management of engineering and technology.
- One hundred and eleven (111) 12th-grade high school students from all over the country studying the industrial engineering and management discipline.

  High school students submitted the final project at two different levels:
  - Seventy-three (73) students submitted the final project at a basic level.
  - Thirty-eight (38) students submitted the final project at an advanced level.

The essential difference between the final project at a basic level and an advanced level is in the number of topics included within the project, as well as the type of engineering tools used to analyze the findings.

A. Research Tool: A Questionnaire for Assessing Students' CEST

The objective of this tool was to assess the CEST level of questionnaire respondents. The questionnaire, which was based on an existing questionnaire from the research literature, underwent several revisions and was adapted to the current research objective. The original questionnaire was developed by [9]. This tool was intended to select and promote engineers, select work candidates, and analyze and assess systems engineering curricula.

To adapt the questionnaire to the current study needs, the statements were revised to suit the assessment of students' CEST, as expressed during their work on their project. The modified questionnaire was then distributed to three judges, all experts in the field of management of engineering and technology, and experienced in mentoring projects in this area. After analyzing their responses, a revised questionnaire was formulated comprising 31 sets of sentences. For each set, the student was requested to indicate whether:

a. He/she agreed more with Sentence A.
b. He/she agreed more with Sentence B.

For example:

A. When I propose a solution to improve an existing situation in the project, I am aware of non-engineering considerations, such as business and economic considerations.
B. When I propose a solution to improve an existing situation in the project, I focus only on operational and engineering considerations.

(The CEST student is expected to choose Sentence A in this example.)

The students were instructed to choose the sentence they agreed with most and were told that there was no correct choice. When a research subject chose a sentence that gave evidence of CEST, three points were awarded; when the subject chose a sentence that did not, no points were awarded. Therefore, the maximum score for the questionnaire is 93 (31 statements / attitudes x 3 points). To reduce the tendency for the research subjects to automatically choose an answer out of boredom, fatigue, or lack of motivation without reading the contents of the item in full, the questionnaire was formulated in such a way that CEST was sometimes reflected by statements that appeared in Sentence A and other times in Sentence B. All of the statements are based on findings from the study carried out by [9].

The questionnaire was distributed twice: (1) as a pre-questionnaire at the beginning of the school year—at the beginning of Grade 12 for high school students and the beginning of the fourth year of studies for university students; and (2) as a post-questionnaire at the end of their studies. The objective was to determine if a change had occurred among the research subjects in regard to CEST as a result of performing a project. An additional objective was to see if a difference was observed in this change between senior and younger students, and between young students submitting a final project at basic level and young students submitting a project at an advanced level.

B. Questionnaire Validity and Reliability

The questionnaire was structured based on an existing questionnaire developed by [9]. It underwent several revisions to adapt it to the current study. The basic assumption in this research study is that the area being examined (CEST) is homogenous, whereby an examination of internal consistency between items in the questionnaire is made using Cronbach's alpha. The reliability of the original questionnaire was verified using Cronbach's alpha and was found to be fairly high (0.855) [9]. The result from the revised questionnaire was 0.706 for the 31 items in the questionnaire. After removing four items from the questionnaire, the Cronbach's alpha was slightly higher at 0.765.

Another measurement of reliability examined was *interjudge reliability*. The questionnaire was distributed to three experts in the field of management of engineering and technology, all of whom had experience in judging projects in this area. After analyzing their answers, several items in the questionnaire were revised.

Because four factors that characterized engineering systems thinking were already identified in the research study by [9], a confirmatory factor analysis (CFA) was made in the current study. Based on the division by [9] according to which engineering systems thinking includes four different aspects—knowledge, individual traits, cognitive characteristics, and capabilities—we formulated a suitable structural model in the program using AMOS software. For each latent variable, we matched relevant items in the questionnaire (indicators) and removed items that did not fit any of the latent variables.

IV. RESEARCH FINDINGS

To analyze the questionnaire findings, we used the repeated measures ANOVA. The repeated measures ANOVA is suitable for the current study in which two measurements were made for each study subject (pre and post). Therefore, this is a mixed design within-subjects and between-subjects research. The dependent variable reflecting the difference between repeated measures is called Time; this is the within-subject factor. The questionnaire score at the beginning of the year was called the *prefinal_mark,* and the score at the end of the year the *postfinal_mark*. Table 1 presents this variable.

TABLE 1. WITHIN-SUBJECT FACTORS

Time	Dependent variable
1	prefinal_mark
2	postfinal_mark

The variable reflecting the three research groups is *project type* (senior students, high school students basic group, and high school students advanced group) and is shown in Table 2.

TABLE 2. BETWEEN-SUBJECT FACTORS

		Value label	N
Project	1	Senior students	42
	3	High school- basic	73
	5	High school- advanced	38

In Table 3, we present the results of the repeated measures variance analysis in the current study according to the general linear model. An essential difference is observed among the students in Table 3 regarding their scores in the pre- and post-questionnaires. The senior students started out with an initial average score that was significantly higher (68.79) than that of the young students, and they improved their average score in the post-questionnaire (77.79). In comparison, the young students in the basic and advanced level improved their initial scores only very slightly (for example, the young students in the basic level group improved their average score from 60.41 in the pre-questionnaire to 61.85 in the post-questionnaire).

To verify whether a significant heterogeneity level exists in the sphericity of measurements, we used Mauchly's Sphericity Test to test for sphericity. Table 4 presents the results of this test. If the results are insignificant, we can assume that sphericity of measurements exists; therefore, we can use regular F tests called *Sphericity Assumed*. The results of this text are insignificant (Sig =.); therefore, it can be assumed that an assumption of sphericity of measurements exists and we can use the regular F tests.

Table 5 presents the results of the ANOVA test and their significance in comparing the scores in the questionnaires at both points in time. The values that we present in Table 5 appear in the Sphericity Assumed row, since the sphericity test was found to be insignificant (see Table 4). In this row, a significant difference was found for the time source in the questionnaire score at both time points (Sig = 0.001; F(1,150) = 12.374). The importance of this is that the influence of time on the questionnaire score is significant for each within-subject group. Similarly, in the Sphericity Assumed row, the interaction between project type and time (time*project) was found to be significant (Sig = 0.01; F(2,150) = 4.801). This means a significant interaction existed between project type and time when the questionnaire was filled out.

TABLE 3. DESCRIPTIVE STATISTIC MEASUREMENTS IN THE REPEATED MEASURES VARIANCE ANALYSIS

	Project	Mean	*SD*	N
prefinal_mark	Senior students	68.79	13.730	42
	High school- basic	60.41	12.128	73
	High school- advanced	58.66	11.518	38
	Total	62.27	13.018	153
postfinal_mark	Senior students	77.79	8.418	42
	High school- basic	61.85	10.218	73
	High school- advanced	60.16	11.115	38
	Total	65.80	12.401	153

TABLE 4. RESULTS OF THE SPHERICITY TEST IN THE REPEATED MEASURES VARIANCE ANALYSIS

Measure: MEASURE_1				
Within-subjects effect	Mauchly's W	Approximate chi-square	*df*	Sig.
Time	1.000	0.000	0	.

TABLE 5. RESULTS OF REPEATED MEASURES VARIANCE ANALYSIS (TEST OF WITHIN-SUBJECTS EFFECTS)

Measure: MEASURE_1						
Source		Type III sum of squares	*df*	Mean square	F	Sig
Time	Sphericity Assumed	1,116.543	1	1,116.543	12.374	0.001
	Greenhouse-Geisser	1,116.543	1.000	1,116.543	12.374	0.001
	Huynh-Feldt	1,116.543	1.000	1,116.543	12.374	0.001
	Lower-bound	1,116.543	1.000	1,116.543	12.374	0.001
Time*project	Sphericity Assumed	866.323	2	433.161	4.801	0.010
	Greenhouse-Geisser	866.323	2.000	433.161	4.801	0.010
	Huynh-Feldt	866.323	2.000	433.161	4.801	0.010
	Lower-bound	866.323	2.000	433.161	4.801	0.010
Error (time)	Sphericity Assumed	13,534.736	150	90.232		
	Greenhouse-Geisser	13,534.736	150.000	90.232		
	Huynh-Feldt	13,534.736	150.000	90.232		

TABLE 6. RESULTS OF REPEATED MEASURES VARIANCE ANALYSIS FOR DIFFERENT PROJECT TYPES

Measure: MEASURE_1					
Transformed Variable: Average					
Source	Type III sum of squares	*df*	Mean square	F	Sig
Intercept	1,177,227.307	1	1,177,227.307	7,153.201	0.000
Project	10,047.504	2	5,023.752	30.526	0.000
Error	24,686.026	150	164.574		

Table 6 presents the results of the ANOVA test comparing questionnaire scores for the different project types. Table 6 reveals a significant difference between the different project types (senior students' projects, young students at the basic level, and young students at the advanced level) regarding questionnaire scores (Sig = 0.00; F(2,150) = 30.526).

In summary, according to the analysis of the questionnaire findings assessing engineering systems thinking capacity, we found that a significant difference exists between the achievements of senior students and those of young students. The senior students started working on their project with a higher CEST and exhibited a more significant improvement in this capacity as a result of working on their project. The questionnaire makes a significant differentiation between the engineering systems thinking capacities of senior and young students.

Questionnaire Analysis—Assessing Engineering Systems Thinking Capacity According To Different Characteristics (Cognitive Characteristics, Capabilities, Individual Traits, and Knowledge)

The questionnaire analysis presented up until now has been general and has not related to categorizing the questionnaire items according to their different characteristics. We will now present an analysis of the questionnaire by dividing the items into the characteristics comprising engineering systems thinking.

According to a division presented by [9] and [11], and based on an exploratory factor analysis, the questionnaire was divided into the following characteristics:

- Eleven questions testing **cognitive characteristics** (whereby the maximum score is 33 points, 3 points per question when the study subject answers that he is a "systems thinker from the cognitive aspect").
- Six questions testing **CEST** (maximum score is 18 points).
- Nine questions testing **individual traits** (maximum score is 27 points).
- Five questions testing **knowledge** (maximum score is 15 points).

In Table 7, we present the improvement among the senior students regarding each of these characteristics. As a reminder, in the previous analysis, no significant improvement was observed in the measure of CEST in young students over time. In examining the different characteristics among senior students, we found that the most significant improvement took place in regard to cognitive characteristics (an improvement of 16.53%) and knowledge (17.66%).

An analysis of the engineering systems thinking questionnaire findings, according to the different characteristics defined by [9], confirms the findings from the analysis of the complete questionnaire. These findings report that, when comparing the achievements of the different study groups regarding each of the characteristics in the questionnaire (cognitive, capabilities, individual traits, knowledge), a significant difference was observed between senior and young students. In addition, similar to the findings from the analysis of the complete questionnaire, no significant difference was observed between the groups of young students (those at the basic level and those at the advanced level). However, it is important to mention that, regarding the cognitive and knowledge characteristics, young students studying at the basic level had an advantage over young students studying at the advanced level, even though this advantage was not significant. The most significant improvement among young students at the advanced level was observed in relation to the capabilities characteristic.

TABLE 7. PERCENTAGE OF IMPROVEMENT IN EACH CHARACTERISTIC OF THE QUESTIONNAIRE—ASSESSING ENGINEERING SYSTEMS THINKING CAPACITY AMONG THE SENIOR STUDENTS

Characteristic	Average score on the pre-test	Average score on the post-test	Difference between the average pre-test score and average post-test score	Percentage of improvement on the average pre-test score and average post-test score, %
Cognitive	23.4762	27.3571	3.8809	16.53
Capabilities	11.7857	11.9286	0.1429	1.21
Individual traits	21.9286	24.8571	2.9285	13.35
Knowledge	11.5952	13.6429	2.0477	17.66

V. CONCLUSIONS AND RECOMMENDATIONS

From an analysis of the study findings, we can conclude that the capstone project could generate a change in overall CEST among students. Systems thinking enables the learner performing a project to perceive and understand the entire system without understanding its details, to analyze the marketing aspects, marketing needs, business opportunities, and all other aspects that could promote the organization and improve its performance. In addition, in performing the capstone project, the learner is required to connect between different topics and implement them in practice, while using statistical, engineering, and operational tools. The learner is also required to integrate several areas, such as quantitative estimations of cost versus efficiency, a study of organizational processes, a functional analysis, market needs, etc. All these contribute to developing an engineering systems thinking capacity in performing the project. The study findings confirm the assumption that CEST is a combination of inherent and acquired abilities.

One of the most significant findings of this study is the improvement observed in CEST as a result of the experience gained in performing project. The most significant improvement was found among the senior students. This reinforces the assumption that engineering systems thinking capacity can be improved when learners deal with multi- and interdisciplinary learning environment.

The systems engineering approach is very important in a complex projects-based environment. Engineers and managers involved in project development, who have a strong CEST and are capable of analyzing the needs and requirements of customers, developing operational approaches to conceptualizing the solution, generating logical solutions (functional and architectural analysis), using simulations and optimization analyses to apply system design considerations, and performing market surveys that could lead to alterative solutions.

Systems thinking aids decision-making processes at all levels, up to the strategic level in an organization. Engineers and managers who have acquired systems thinking are capable of successfully managing tasks and projects cross-organizationally, being able to see the big picture.

In conclusion, the study demonstrates that it is possible to improve systems thinking while performing multidisciplinary projects. The study conclusions confirm the assumption that the capacity for systems thinking is a combination of inherent and acquired abilities.

Our study aims to identify the abilities, cognitive characteristics (thinking skills), and individual traits (behavioral competences) of students with high CEST. The importance of exploring and identifying these characteristics is that they can become keystones for developing (1) training classes, university programs, and curricula for building up systems thinking in engineers and managers; (2) a plan for accelerating the development of engineers and managers through job design, job rotations, and development programs; and (3) a test for assessing CEST. This test can be used for selection, filtering, screening, placement, and classification of candidates for engineering and management positions that require high CEST [8].

As the systems of the world become increasingly complex, many systems thinking practices may prove beneficial when it comes to problem solving, especially when looking for long-term solutions. Therefore, it is important to accelerate systems thinking development among engineers and managers through education and training.

The conclusions of the study presented here should be verified and validated by additional future studies. It is important to understand the mechanisms behind effective systems thinking development. A deeper understanding of the ways and processes by which systems thinking is developed can provide a better foundation for management of engineering and technology educational programs.

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