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Assessing the Barriers to Implementing Systems Thinking in Organizations Using Interpretive Structural Modeling

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ABSTRACT

Systems thinking is a useful approach to realizing and analyzing real-world phenomena. It helps us to study components of a system jointly rather than individually. In this regard, organizations need systems thinking to strengthen their holistic inclusiveness because it aids managers examine structures, patterns, and events about each other and not just observing events. Even though applications of systems thinking have been the center of scholars' attention, barriers, and factors that cause organizations to impair systems thinking have not appropriately been addressed and have been paid less attention. The passage of six decades of systems thinking as a theoretical-practical approach implies that it is appropriate that the field of growth and promotion of this effective thinking in the management of society and organization are given more attention by managers and decision-makers. Therefore, this study has been carried out to identify and analyze the barriers to systems thinking in Iranian organizations using the interpretive structural modeling (ISM) technique. This method is one of the system analysis methods and examines the interactions between system elements. In this study, after a comprehensive review of the research literature, 64 factors were extracted, combined as much as possible, and finally, the identified barriers were reduced to 7 categories. The results of the ISM model divided these 7 categories of factors (general barriers) into three levels of importance and effectiveness. Organizational, cultural, financial, educational, and personality factors were at the first level of influence. The mental factor took the second position, and the information factor took the third place. It can be mentioned that the managers should pay special attention to 5 factors in the first level as they are the most effective factors that concentration on them can lead to successful systems thinking in organizations.

Keywords

Systems Thinking, ISM, Implementation Barriers, Organization.

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1. Introduction

Systems thinking is a knowledge-based approach that focuses on recognizing, building, and predicting complicated systems as correlated individuals, not unrelated ones (Mambrey et.al, 2020). This way of thinking provides an effective methodology for socio-cultural systems in an environment full of confusion and complexity. There is no doubt that technological advancements in areas such as the Internet, GPS, power grid, and software APIs have led to increasing interdependence among different systems (Arnold and Wade, 2015). In this regard, organizations are interested in recreating their business models because of the increasing growth of technological and economic achievements (Hossain et al., 2020). To this end, systems thinking not only addresses the components and details of a system but also considers how the components interact as well as the interaction of components and the environment. In fact, this type of thinking seeks to understand the whole (system) and its components, the relationship between the components, and the relationship between the whole and its environment (Singh, 1990). Since our behavior is rooted in our system of thought, someone who has systems thinking also deals with issues systematically and, in his behaviors, seeks to identify the elements that make up the subject and the connections between these elements. In this way, the person who thinks in a system is not just looking for a set of features of the subject; rather, systems thinking helps him to look at issues comprehensively and systematically (Binesh, 2011).

Nonlinear thinking and a dynamic view of phenomena and consequences are the neglected points of managers' decisions in businesses and commercial and non-commercial organizations. Ignoring the inherent dynamics of phenomena leads to poor quality decisions that, instead of solving a problem, bring about new problems and challenges. Unfortunately, the number of such decisions at various levels of Iranian firms and organizations is not small, and even in our personal lives, we suffer from the consequences of linear and static thinking. (Mohammadi, 2017). Although many benefits have been mentioned for systems thinking, they are unfortunately not appropriately accepted and considered by Iranian organizations. There are many reasons for this, including the fact that humans are naturally inclined to deconstruct and prefer to remain in their past mental structures.

Moreover, human knowledge has been formed mainly based on partial mind and lead to ability reduction to understand many issues. This issue has also made "communication" difficult because, with the partial mind, it is not possible to produce communication tools (Khaldun,

2004). Unfortunately, in today's organizations, despite the significant progress they have made in human resources, there is no common language of communication between employees and members, which slows down their movement and progress. Also, organizations cannot identify and select the right solutions to many problems and issues. One of the reasons for the lack of communication between members, lack of identification of problems, and failure to provide appropriate answers to them, is the lack of systems thinking in organizations. In other words, systems thinking barriers are factors that impede the implementation of systems thinking.

Various researches have studied systems thinking barriers such as traditional management, communist and mechanistic perspective, lack of interdisciplinary thinking, lack of voluntary communication to increase the systemic ability, and asymmetric information in the digital age (Basile and Caputo, 2017; Low, 2005). But a systematic view of barriers has received less attention, so it is necessary to study this subject more. Hence, presenting a suitable approach to identify and prioritize barriers can be beneficial. Until now, the implementation of systems thinking has not been investigated systematically; one of the best methods of systematic investigation of the factors affecting the implementation is the ISM method which will be used. Also, this method efficiently identifies the most effective and affected variables. To this end, this study intends to pay attention to this gap within organizations and identify the factors and barriers to implementing and assessing systems thinking in Iranian organizations. Then, it determines the relationship between these factors based on the opinions of experts in this field. In this study, it is determined what are the barriers to the implementation of systems thinking in Iranian organizations? and how much impact each of them has on this issue?

2. Theoretical framework

2.1. System

The system is a network of interconnected components that work together to achieve a common goal. The greater the degree of dependence on a system, the greater the need for coordination between components. A system is a set of elements that cannot be separated into independent components. We lose our properties if we use theories or systems to separate components. In this regard, the system has a general nature that is not possible with analysis alone. Understanding this is the first source of an intellectual revolution that changed the era and turned the four hundred years old era of "machine" into the era of "system", in the words of "Russell Ackoff " (Ackoff, 2009).

2.2. Systems thinking

Systems thinking is a view of the universe and its phenomena. The basis of systems thinking is the study of the component as a whole, not separately. In systems thinking, we do not separate the system from its environment and only examine the details as a single interaction and separately from time. This is because the performance of a system depends more on how its components interact than on how they function independently. Although the origin of systems thinking and the presentation of the general theory of systems was the science of biology, today, systems thinking is comprehensive and interdisciplinary thinking that provides an effective methodology for socio-cultural systems in an environment full of confusion and complexity. Systems thinking is a set of synergistic analytical skills used to improve the ability to identify and understand systems, predict their behaviors, and modify them to produce desired effects (Arnold and Wade, 2015). These skills work together as a system. The subtlety of this definition lies in its simplicity and application. Due to the lack of background on the nature of a system, this definition can be presented in an understandable way to an audience without a background in system science. The effort of systems thinking is summarized in two elements: reducing complexity by modeling systems conceptually and identifying and understanding nonlinear relationships (Arnold and Wade, 2015). Systems thinking is based on the premise that a system is a set of two or more components with three conditions: a) The behavior of each component depends on the behavior of each whole. B) The behavior of the components and their impact, on the whole, are interdependent. C) Each of the subgroups has an impact on the overall behavior, and the impact of any of them is not independent (Ackoff, 2009).

2.3. Elements of systems thinking

There are many definitions of systems thinking and its principles that, according to review studies (Arnold and Wade, 2015) in research background in the field of systems thinking definitions, including the following concisely::

1. Finding internal relations

This one is the most fundamental principle of systems thinking. It is capable of describing the key relations between different parts of a system. Without learning systems thinking, higher education cannot develop this skill.

2. Defining and understanding feedback

Some internal relations are combined to make cause-and-effect feedback loops. Systems thinking needs to understand and describe the feedback loops, and it also needs to realize how the feedback loops affect the system's behavior.

3. Realization of systems structure

Systems structure is made up of elements and the connections between them. Systems thinking needs to comprehend this structure. Although these elements specifically have not been mentioned in the classification of Hopper and Stave (2008) or Plate (2010), they can be called a combination of the two mentioned elements. And this is mentioned in other important works.

4. Detecting the flow and stock variables

Stock variable refers to the resources in a system. This variable can be physical, like the amount of paint in a bucket, or emotional, like the level of trust between friends. The flow variable is the changes in these levels. Other variables are modifiable parts of the system that affect stock and flow, like flow rate or a maximum of stock. Ability to distinguish between these stock variables, flow variables, and other variables and understanding their performance are important skills of systems thinking.

5. Recognizing and comprehending the nonlinear relationships

This element refers to nonlinear stocks and flows. Conceptually, this element can be grouped as different types of stock, flow, and variables. Nevertheless, the latter is indicative of linear flow. To avoid confusion, nonlinear flows are separated in this element.

6. Understanding the dynamic behavior

Relations, how to combine them with feedback loops, effects of these feedback loops and consists of stock variables, flow variables, and other variables are causes of creating the dynamic behavior in the system. This behavior is incomprehensible without training and understanding of the system (Plate, Monro, 2014). Emergence behavior, the term that is used to describe the behavior of an unpredictable system, is an example of dynamic behavior. Distinguishing between different types of stock variables, flow variables, and other variables also recognize and comprehend the nonlinear relationships, and both are the keys to understanding the dynamic behavior.

7. Reducing the complexity by conceptual modeling of systems

This element is the ability to model the concept of different parts of a system and observe the system in different ways. Performing this action goes beyond the systems models and, through various methods, such as reduction, transformation, summarization, and restatement,

enters the process of intuitive simplification (Wade,2011). This skill can observe the system in different ways reducing the complexity.

8. Understanding Systems at different scales

This skill is similar to Barry Richmond's Forest Thinking (Plate, Monro, 2014). It includes the ability to recognize different scales of systems and systems within systems.

3. Literature review

The studies related to assessing systems thinking or its applications are stated in this literature. Basile and Caputo (2017) conducted a study entitled "Theories and challenges for systems thinking in practice ". They mentioned the challenges of implementing systems thinking in their research. Traditional management, communism, and mechanistic perspective, lack of interdisciplinary thinking, lack of voluntary communication to increase the systemic ability, and asymmetric information in the digital age are examples of challenges that are mentioned in this study. Jacob and Warschauer (2018) conducted a study entitled "Assessing systems thinking: A tool to measure complex reasoning through ill-structured problems". They provided a framework for operationalizing systems thinking. They mentioned two thinking indicators, measurement, and bias on tools. Richmond and Peterson (2001) conducted a study entitled "An introduction to systems thinking ". He introduced three indicators: operational, closed-loop, and nonlinear thinking, as key systems thinking skills. Senge (1990) conducted a study entitled "Systems thinking "that provided methods of implementing systems thinking. He introduced the lack of proper understanding of the issue, lack of understanding of the integrity issue, understanding of the relations between variables, and lack of complexity of the issue as the challenges of systems thinking. Baron (2014) mentioned the barriers to learning in a study entitled "Overcoming barriers in learning cybernetic science". He introduced the following items as barriers to learning: dealing with a single solution and copying from others, using different tools, not the same tool, clearing the issues, not solving them, superficial thinking, lack of understanding the intercultural differences, and inaccuracy in listening and seeing well. Trochim et al. (2006) conducted a study entitled "Practical challenges of systems thinking and modeling in public health". Their goal was to identify and describe the executive challenges of systems thinking in the field of public health. Schuler et al. (2018) conducted a study entitled "Systems thinking within the scope of education for sustainable development – a heuristic competency model as a basis for teacher education". They introduced systems thinking as the main competence in the field of education for sustainable development (ESD) because it helps

students understand the complexity and dynamics of natural and social, and economic systems. They created a competency model that distinguishes the four dimensions of systems thinking in ESD.

Beasley (2012) conducted a study entitled "The barriers to systems thinking". "Systems thinking is a prerequisite for effective systems engineering and is one of the most difficult elements to identify, develop, and use."; he said. Based on the experience of implementing effective and explicit systems engineering in Rolls-Royce, the author offered ideas for overcoming barriers. He also stated that systems thinking should be integrated with the processes and knowledge, roles within the organization, and effective leadership that supports the implementation of systems thinking. Binesh (2011) conducted a study entitled "The barriers to systems thinking". He, in his study, described the components of systems thinking. He also investigated the most important barriers to systems thinking in partial aspects, i.e., focusing on events, projection, the trap of dual thinking, stereotype, formative thinking, attention to signs instead of causes, analytical thinking, and attention to quantity. York et al. (2019) investigated applications of Systems Thinking in STEM Education. They found that systems thinking approaches have generally been used in life sciences, earth sciences, and engineering but not in the physical or mathematical sciences. They realized that the primary emphasis of peer-reviewed publications was on the development of students rather than teachers' systems thinking abilities. Berry et al. (2018) used systems thinking to describe relationships to modern epidemiology and propose adopting a systems approach to remedy present limitations. They outlined existing thoughts about climate change and mental health and discussed vital limitations in modern epidemiology to evaluate this issue. Moscardo (2021) used systems thinking to improve tourism and hospitality. He demonstrated how the systems thinking approach could be implemented to boost both the relevance of and theoretical development in tourism and hospitality research in sustainability. He also showed the power of taking the systems thinking approach to map out the research problem area. Kuo et al. (2020) introduced the concept of systems thinking to enhance the performance of the prediction models. They found that introducing the concept of systems thinking resulted in significant power of the models, indicating that interdisciplinary efforts could potentially improve prediction performance. In their case study, they demonstrated that machine learning algorithms utilizing the systems knowledge could significantly improve the performance of waiting time prediction.

A summary of the research background is given in Table 1:

Table 1. Studies related to the barriers and challenges in systems thinking

code	Research Topic	Author
1	Theories and challenges for systems thinking in practice	Basile and Caputo (2017)
2	Cultural barriers in growing entrepreneurship: A study in singapore	Low, (2005)
3	Assessing systems thinking: a tool to measure complex reasoning through ill-structured problems	Jacob and Warschauer., (2018)
4	An introduction to systems thinking	Richmond and Peterson (2001)
5	The art and practice of the learning organization	Senge (1990)
6	11 laws of systems thinking from peter senge's perspective	Norouzi (2017)
7	Factors affecting the successful implementation of high-performance teams	Castka et al., (2001)
8	Overcoming barriers in learning cybernetic science	Baron (2014)
9	Practical challenges of systems thinking and modeling in public health	Trochim et al., (2006)
10	Systems thinking within the scope of education for sustainable development – a heuristic competence model as a basis for teacher education	Schuler et al., (2018)
11	The barriers to systems thinking	Beasley (2012)
12	Barriers to systems thinking	Binesh (2011)
13	Applications of systems thinking in stem education	York et al., (2019)
14	The case for systems thinking about climate change and mental health	Berry et al., (2018)
15	A systems thinking approach to understanding the challenges of achieving the circular economy	Iacovidou et al., (2021)
16	Using systems thinking to improve tourism and hospitality research quality and relevance: a critical review and conceptual analysis	Moscardo, (2021)
17	An integrated approach of machine learning and systems thinking for waiting time prediction in an emergency department	Kuo et al., (2020)

3.1. Summary of research background

A review of the existing literature on barriers to implementing systems thinking in the world shows that most previous studies have not directly addressed the barriers to implementing systems thinking. (Such as the Secular, 2017 and Richmond and Peterson, 2001). Instead, most studies have addressed the applications of systems thinking in real-world problems, such as Kuo et al. (2020). None of the researchers has collected and examined the barriers to implementing systems thinking in detail, and each has pointed out some of the barriers in a piecemeal manner. (Such as Binesh, 2011 and Beasley, 2012).

Furthermore, the barriers to implementing systems thinking in Iran have not been completely and comprehensively done so far, and only Binesh (2011) has pointed to a limited number of barriers and explained them. No previous research has analyzed the relationship between these barriers and interpretive structural modeling. Therefore, in this study, to identify and assess the barriers to systems thinking as our main contribution, the research in this field from 1990 to the end of 2021 was examined, and the mentioned barriers in them were collected. As a result, it can be said that the present study is innovative in terms of the method and the comprehensive view it applies.

4. Research methodology

This study aimed to investigate the barriers to systems thinking implementation and conduct a systematic model with ISM. A review of the literature was used to identify the barriers. Then, the ISM model was adopted to prioritize the identified barriers. After reviewing the literature and a comprehensive study of its content, 64 major barriers to implementing systems thinking in the first step have been identified. Then, a questionnaire was used to integrate, summarize, and classify the indicators. Also, the opinions of professional and academic experts have been considered to identify and determine the relationship between the identified barriers to the implementation of systems thinking for the development of interpretive structural models (ISM). The approach of this research is exploratory.

In the present study, experts were selected using purposive sampling. Out of different managers and experts in systems thinking in Iran, 8 experts were chosen in order to employ the ISM method and examined the structural relationships between the identified variables.

4.1. Steps of the research process

The steps of conducting research are as follows:

- Extracting indicators from the research literature
- Determining overlaps and merging indicators
- Classification of indicators
- A structural relationship is constructed among the identified variables
- A structural self-interaction matrix (SSIM) is formed for the variables, reflecting the doublet relationships of the variables of the structure under consideration. (See Table 4)
- A reachability matrix is formed from the SSIM, then scanned for transitivity. (See Table 5)
- In this step, the formed reachability matrix is further subdivided into 2 levels. (See Table 6 and 7 Iteration i-ii)
- In this step from the reachability matrix, a direct graph is drawn, and the transistive assocaion are detached. (see Figure 1)

In the following subsections, we will explain each in detail.

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4.1.1. Extracting indicators from the research literature

In the first stage, the library study method was used to be fully acquainted with the subject, study the research background, and determine the barriers to implementing systems thinking. In order to identify the barriers to systems thinking, related works from 1990 to the end of 2021 were reviewed, barriers were extracted from the previous studies, and their importance in the systems thinking literature was investigated. The number of studies conducted in this field is very limited, and most researchers have not directly mentioned the barriers. At this stage, the content was entirely studied to extract the largest number of indicators. Even the indirectly mentioned cases in the articles were studied and extracted. Finally, a comprehensive list of dimensions and barriers was prepared, and 64 factors (barriers) were identified.

4.1.2. Determining overlaps, merging indicators, and classifying indicators

In the second stage, by sending a questionnaire to 8 academic experts with relevant education and experience, we localize and finalize the factors identified in the first stage. At this stage, after discussion by the expert team, some indicators were merged, and some overlaps were removed. Finally, all indicators were summarized and finalized in 25 indicators. In Table 2, the names of the indicators, their operational definitions, and the sources from which these indicators are extracted are mentioned. (Based on the codes in Table 1)

In the next step, in order to reduce and summarize the indicators for pairwise comparisons, using the opinions of the expert team, 25 barriers were classified into 7 categories, and these 7 categories were used as input to the next step. The findings of this stage are combined with the previous stage and are listed in Table 2.

Table 2. Operational definitions of dimensions

Code	Operational definition	Name	Category	Row
4	Management based on old schools such as Classic, Taylor, Weber, etc.	Traditional management	Organizational	1
4, 12	Existence of multifaceted thinking, from a multidisciplinary and multidimensional perspective on a subject, development of a mission, and integrated vision between different departments and layers (neighborhood, regional, national and international)	Lack of interdisciplinary and transregional thinking	Cultural	2
4,14,15	People's mental frameworks in their learning process	Stereotyped thinking	Mental	3
5,7	The skill by which a person acquires new thoughts or relationships with the help of problem-solving and decision making and finds the power to discover and choose new solutions.	Lack of creative thinking and soft skills	Mental	4
7,9,15	Linear consideration of cause and effect relationships	Linear thinking	Mental	5
8	Lack of proper understanding of the issue	Lack of proper understanding of the issue	Mental	6
8,14	Lack of understanding of the complexity of the problem due to the existence of complex and large organizations	Lack of understanding of the complexity of the problem	Mental	7
8	Lack of understanding of the integrity of the problem and understanding of the relationships between variables	Lack of understanding of the integrity of the problem	Mental	8
9,11	Controlling the effects of a problem instead of solving the root of the problem is simplistic	Superficial thinking	Personality	9
9,12,14	Searching for the Most Available Cause, Looking for a Quick and Efficient Solution Instead of Finding a Sustainable Solution, Ignoring Delay	Short-sighted thinking	Personality	10
4,9,15	Divide the system and try to analyze the parts independently	Analytical and mechanical thinking	Mental	11
9,15	Negativity and blaming environmental conditions	Projecting	Personality	12
4,9,10, 11,12,1 4	Barriers such as task-oriented organizational structure, individual performance appraisal, lack of systems thinking in evaluation indicators, lack of team culture in the organization, lack of encouragement and motivation of systems thinking, lack of necessary infrastructure and resources, lack of systems thinking in macro goals and programs, policies and bureaucracy	Organizational barriers	Organizational	13
4,10,12 ,13,14	Lack of sufficient knowledge to solve problems among team members, lack of training in systems thinking, training based on simple examples and lack of equipping people with complex techniques to deal with real problems	Lack of sufficient knowledge and skills	Educational	14
11	Clear problems instead of solving them	Clear the problem	Personality	15
11	People do not pay attention to listening and seeing carefully	Inaccuracy in what is heard and seen	Personality	16

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Code	Operational definition	Name	Category	Row
12	Develop methods and tools that encourage a systems approach, identify and disseminate examples of "best practices" or "best practices" in systems thinking	Lack of methods and tools of systems thinking	Educational	17
12	Lack of financial resources for its inclusion and further training	Lack of financial resources	Financial	18
12	Lack of support from the authorities for team building and the pervasiveness of systems thinking	Lack of official support for systems thinking	Organizational	19
14	Use methods to prove the value and identity of systems thinking	Lack of proof of the value of systems thinking	Cultural	20
4,14	Barriers such as not allocating enough time to get more information, insufficient information, lack of access to information, thinking about the size of previous uncertainties, and seeking to recognize new uncertainties, dispersion, and large and erratic amount of information in the new age	Information barriers	Informational	21
14,15	With the instability of problems and their constant change, the human mind is not able to understand the dynamics of the problem and process all information simultaneously. Focusing on events prevents us from finding the pattern of long-term change behind events.	Difficulty understanding the dynamics of the problem	Mental	22
14	The nature of program and project management tends to progress quickly and according to plan and does not allow for a proper understanding of the system	The linear nature of tracking project progress	Organizational	23
14	Standardize and share problem-solving with a dynamic system approach	Lack of standards for solving problems	Educational	24
15	Paying attention only to numbers and figures, paying attention to size or numbers, is a category that, in Russell Ackoff, is related to "growth", not "development", while systems thinking is a developmentalist thinking.	Paying too much attention to the quantity	Educational	25

4.1.3. Preparation and completion of Interpretive Structural Modelling (ISM) questionnaire for final indicators

In the third stage, the pairwise comparison questionnaire was used to extract experts' opinions in identifying and analyzing the relationships between barriers in the form of interpretive structural modeling. For this research, the ISM method has been used. This method is an interactive learning process in which a set of different interrelated elements are structured in a comprehensive systematic model (Warfield, 1974). This methodology helps to create and direct complex relationships between the elements of a system (Faisal et al., 2006). One of the

main areas of this method is that the elements that have a greater impact on other elements in a system are always more important. The model obtained using this methodology shows the structure of a complex problem or topic, a system or field of study that is a carefully designed model (Faisal et al., 2006).

As a result, we can say that interpretive structural modeling not only provides insight into the relationships between the various elements of a system but also provides a structure based on the importance or impact of the elements on each other and displays a visual representation. This is an interpretive method because the judgment of a group of people determines whether there are relationships between elements. This is a structural method because the basis of relationships is a global structure derived from a complex set of variables.

4.1.4. Structural Self-Interactive Matrix Formation (SSIM)

In this step, the experts consider the criteria in pairs and respond to the pair comparisons based on the following. That is, in each comparison, the two criteria use the letters V, A, X, O based on the following definitions.

V: The factor of row i causes the factor of column j to be realized.

A: The factor of column j causes the factor of row i to be realized.

X: Both row and column factors cause each other to be realized (factors i and j have a two-way relationship).

O: There is no relationship between the row and column factor.

Table 3 shows the results of expert opinions and pairwise comparisons.

Table 3. Structural self-interaction Matrix (SSIM)

Information	Financial	Educational	Personality	Mental	Cultural	Organizational	
V	**V**	**X**	**X**	**O**	**A**	**-**	Organizational
V	**X**	**X**	**X**	**O**	**-**	**V**	Cultural
A	**0**	**A**	**X**	**-**	**O**	**O**	Mental
V	**O**	**A**	**-**	**X**	**X**	**X**	Personality
V	**A**	**-**	**V**	**V**	**X**	**X**	Educational
O	**-**	**V**	**O**	**O**	**X**	**A**	Financial
-	**O**	**A**	**A**	**V**	**A**	**A**	Informational

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4.1.5. Obtaining the initial achievement matrix

This matrix is obtained by converting the symbols of the SSIM matrix to numbers zero and one based on the initial access matrix.The four symbols used to indicate the direction of the i and j relationship are as follows:

- V: variable i leads to variable j.
- A: variable j leads to the variable i.
- X : a bidirectional relationship (from i to j and from j to i)
- O: no relationship between the variables.

Table 4 shows the results of this step.

Table 4. translation SSIM to binary matrix

Information	Financial	Educational	Personality	Mental	Cultural	Organizational	
1	1	1	1	0	0		Organizational
1	1	1	1	0		1	Cultural
0	0	0	1		0	0	Mental
1	0	0		1	1	1	Personality
1	0		1	1	1	1	Educational
0		1	0	0	1	0	Financial
	0	0	0	1	0	0	Informational

4.1.6. Matching the achievement matrix

Once the initial access matrix is obtained, the final access matrix is obtained by considering the exponential relations between the criteria. In the initial achievement matrix, the rule must be checked that if criterion A is related to criterion B and criterion B is related to criterion C, then criterion A must also be related to C. The numbers marked with a* in Table 5 are obtained by diffusion relationship.

Table 5. Final Reachability matrix

Information	Financial	Educational	Personality	Mental	Cultural	Organizational	
1	1	1	1	1*	1*	-	Organizational
1	1	1	1	1*	-	1	Cultural
0	0	0	1	-	1*	1*	Mental
1	1*	1*	-	1	1	1	Personality
1	1*	-	1	1	1	1	Educational
1*	-	1	1*	1*	1	1*	Financial
-	0	0	0	1	1*	1*	Informational

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4.1.7. Determining the level of variables

In this step, the set of input criteria (prerequisite-initial set) and output (achievement) for each criterion are calculated, and then the common factors are identified. In this step, the criterion has the highest ISM level that the output set (achievement) is equal to the common set. After identifying these variables, their rows and columns are removed from the table, and the operation is repeated on the other criteria. The results of this step are given in Table 6 and 7.

Table 6. Iteration

Level	Intersection set	Antecedent Set	Reachability Set	Criterion
1	2,3,4,5,6,7	2,3,4,5,6,7	2,3,4,5,6,7	Organizational
1	1,3,4,5,6,7	1,3,4,5,6,7	1,3,4,5,6,7	Cultural
	1,2,4	1,2,4,5,6,7	1,2,4	Mental
1	1,2,3,5,6,7	1,2,3,5,6,7	1,2,3,5,6,7	Personality
1	1,2,3,4,6,7	1,2,3,4,6,7	1,2,3,4,6,7	Educational
1	1,2,3,4,5,7	1,2,3,4,5,7	1,2,3,4,5,7	Financial
	1,2	1,2,4,5,6	1,2,3	Informational

Table 7. Iteration ii

Level	Intersection set	Antecedent Set	Reachability Set	Criterion
2	1,2,4	1,2,4,5,6,7	1,2,4	Mental
3	1,2	1,2,4,5,6,7	1,2,3	Informational

4.2. Mapping network interactions

In this step, according to the levels of criteria in ISM and the relationships between them, a network of interactions is created. The network is shown in Figure 1.

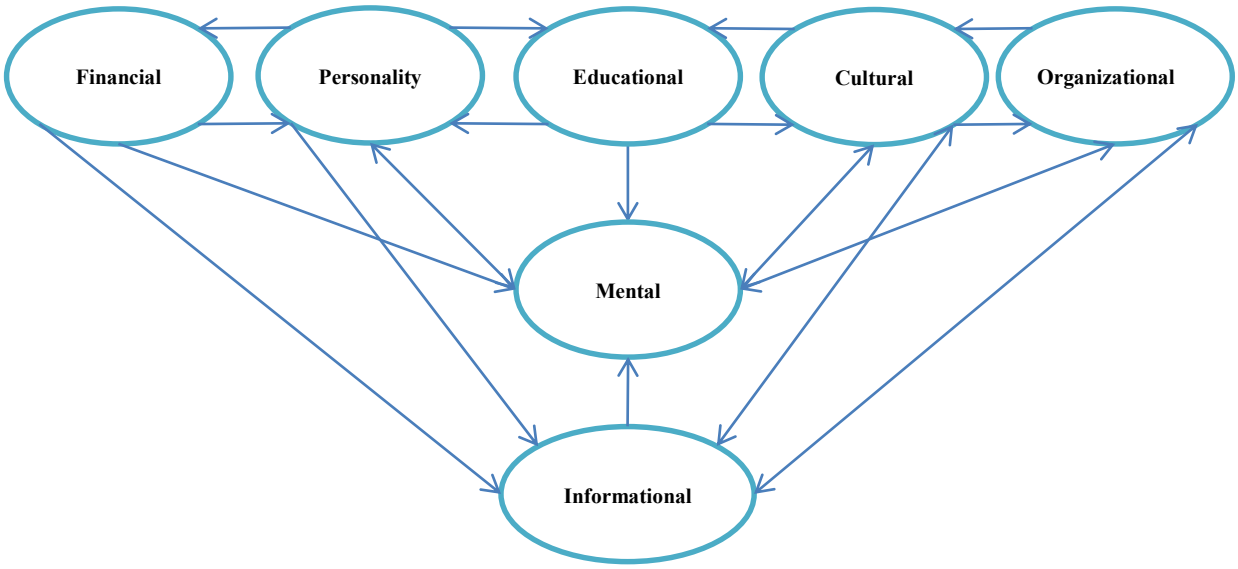

Figure 1. The relationships between criteria

5. Discussion and conclusion

In the present study, first, the barriers to the implementation of systems thinking in organizations were identified and finalized. Then, using the interpretive structural modeling technique, their relationships and leveling were performed. It is interesting to note that some of the variables, such as "cultural barriers", have been indicated directly by some authors like Baron (2014), but some of them are mentioned indirectly (Beasley, 2012; Binesh, 2011; Trochim et al. 2006). According to the hierarchical conceptual model of the ISM method and Tables 7 and 8, "organizational", "cultural", "personality", "educational", and "financial" barriers act as the most important criteria of this model and removing barriers to the implementation of systems thinking should start from these barriers and extends to other barriers at lower levels. The informational barrier has the most impact and the least impact on other factors in the model. Therefore, by removing other barriers, this barrier will be removed to a large extent on its own. Mental barriers are in the middle of the model and are not very effective. Furthermore, by examining the following factors in this category, it can be understood that these factors cannot be eliminated directly to a large extent or that change in them is hardly possible. In conclusion, it is an interesting fact that all previous studies have not investigated systems thinking barriers completely and have not had a systematic view and review of them. Therefore, it is clear that this study has a contribution and innovation in investigating systems thinking barriers and can lead to organizational improvement totally, through systems thinking implementation.

One of the important points that can be deduced from the conceptual model between factors is that almost all factors have two-way relations with each other; that is, they are strongly interdependent. Change in one leads to change in other factors; in other words, it can be said that improvement in each category leads to the exponential growth and development of systems thinking in organizations.

According to the results, suggestions can be made to organizations in Iran. The results showed that 5 categories of factors: "organizational", "cultural", "personality", "educational", and "financial" are among the most important factors, and organizations' funds should be allocated to education, personality, and cultural dimensions of individuals in the organization that affect and improve all 5 factors simultaneously.

Organizations can clearly understand what needs to be improved by examining these sub-factors. For example, "lack of sufficient knowledge and skills", "lack of methods and tools of systems thinking", "lack of standards for problem-solving", and "excessive attention to

quantity", which fall into the category of educational factors, should be the agenda of the training department of all organizations. Of course, the education ministry and higher education departments must simultaneously pay attention to these indicators in their educational content and include them in education from primary to university. Also, due to the unfamiliarity of some industry workers with the concept of systems thinking, it is suggested that seminars, scientific conferences, and workshops in the field of systems thinking to be held by the organizations themselves or by the Industrial Towns Company. In addition, industrial consulting units should be set up by industrial estates.

Considering the importance and the first level of financial factor, it is suggested that organizations consider special and separate budgets for training and evaluation based on systems thinking and take steps to improve and develop the level of systems thinking in organizations. Organizational factors, such as traditional management, linear nature of project progress, lack of support from officials for systems thinking, and other organizational factors show that there is a need for managers and senior officials to pay more attention to the dimensions of systems thinking and its implementation. They should discard their old views and update their management style with new ones that are fundamental for developing systems thinking. Moreover, to influence individuals' personality issues, they can be given correct and principled training in this field. Due to the relationship between this factor and other factors, changes in individuals' intellectual style and personality lead to changes in cultural and organizational factors, becoming mental, information, and so on.

Cultural factors, such as "lack of interdisciplinary and transregional thinking" and "failure to prove the value of systems thinking culture", can also be reinforced by propaganda and culture development. It is necessary to influence the people of the society in this field and penetrate their culture to raise their perspective from the level of the individual to the team, the society, and beyond.

Given that each of the investigated factors can be different from organization to organization and depending on the type of organization (production or service), some factors may be more prominent in this category of organizations; it is recommended that in the next studies, one focus on different organizations as case studies and extract implementation barriers in each organization separately. These barriers can also be examined in different industries, and the results are compared. Using methods such as structural equations is recommended to statistically validate the model presented in this study. In fact, the use of structural equations, in this case, plays a complementary role to the ISM model. Other factor analysis approaches

are also suggested to be used to identify categories in future studies. Other methods, such as DEMATEL, can also be used to analyze the relationship between factors, and the results can be compared with this method. Also, it is suggested that this model be combined with the QFD model.

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