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Original Article

Exploring the Feasibility of Applying a Conceptual Model of Soft Systems Methodology in Implementing a Management Information System in Universities of Medical Sciences Incubators

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Abstract

Introduction: A management information system (MIS) can have a great effect on the effectiveness and efficiency of management in different centers. Various conceptual models are used for designing, implementing, and evaluating this system.

Methods: The Soft Systems Methodology (SSM) is one of those models in which the underlying and effective factors of an MIS are identified, evaluated and clarified, making it possible to design, implement, apply and evaluate the system by using different techniques and the opinions of different experts and managers and reaching a consensus among different attitudes. In this model, the designer and all stakeholders participate in the system; identify the needs, expectations, possibilities, and problems; and offer step-by-step solutions to implement the MIS.

Results: The purpose of this study was to investigate the possibility of using the conceptual model of soft systems method to design and implement information management system in incubators of medical universities. This is a practical descriptive study conducted during the period 2017-2019. This study showed a significant difference in all selected indices ($P<0.05$). It seems that all the indicators have been improved and the implementation of a comprehensive management information system has had a positive effect on their improvement, but there is no significant difference in the index of increasing creative work efficiency ($P>0.05$).

Conclusion: It was concluded that, among the conceptual models, the SSM can be used as an appropriate model for implementing an MIS, and the system developed in this project is efficient enough to be used in the management of the incubator.

Keywords: Management information system, Incubator, Soft systems metothology and CATWOE checklist.

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Background

Today, quick and easy access to correct information required is a determining factor in the success of organizations (1). Since the late 1990s, when the information was regularly disseminated widely through computer networks as well as other electronic devices, network administrators became information managers, and information management included the management and collection of information from one or more sources and the provision of that information to one or more addressees (2). Today, the success of a manager in organizational affairs requires having information to be used in the decision-making process and, first of all, being equipped with a fast and reliable information system and network to receive data and communicate orders (3). Management information systems (MIS) affect the efficiency of organizations in issues such as financial benefits, job development, cognition, management, and work-life balance of employees in interaction with other internal and external stakeholders (4). The ultimate goal of a management information system is to provide information to managers to assist them in the decision-making process (5). Since the preparation and implementation of a scientific, effective and desirable management system usually faces a number of challenges and problems, the officials of

organizations usually choose a method that increases the speed of preparation and implementation of the system, has the least cost and loss for the organization, and most importantly, can be gradually expanded and completed to meet the needs and requirements of the system and management and ensure the reliability of the system. The creation and development of management information systems is usually based on predetermined classical models. In this regard, various models have been introduced, among which we can mention the Luming model, Jeffrey Hofer model, and the four-stage model. These classic models can be used in the design of management systems and can better meet the needs of various organizations, especially high-rank organizations, to improve their management processes (6).

In classical models, typically, the stages of designing, planning, conceptual design, detailed design, and implementation are defined and are subject to predetermined conditions and formats (7). These definitions cannot be fully adapted to the changing conditions in the organizational structure and management information needs of start-ups. In start-up organizations, creative, innovative, up-to-date, and efficient human activities have a central place, and these make it impossible to design management information systems for them using classical models with predefined structures. For MIS that fits the characteristics of these start-ups, it may be possible to use other models based on new research methods in management. In the techniques and tools of modern research methods in management, various methodologies such as Soft System Methodology (SSM), Interpretive Structural Modeling (ISM), Future Study (FS), Cognitive Mapping (CM) and data foundation theorizing, Q methodology, meta-composition and action research are used, which if used correctly, it is possible to create surprising developments in upgrading start-up organizational processes (8).

Articles conducted in this area were surveyed; in an article on the evaluation of the relationship between sustainability and ICT, Raoul Govi et al. showed that investment in this regard was considered as a reason for increasing the economic productivity (9). Also, "Ain Tattoo Team" in a case study on performance management practices in Ghana has reviewed the issues such as increasing employee satisfaction, increasing the speed of action of employees and managers, simplifying the procedures from the point of view of employees and ease of access to information by managers while implementing a management information system. (10). Also, in a study entitled "Towards the Integration of Systems Engineering and Project Management Processes to Assist in Decision Making", Lech Hub et al. addressed issues such as the need to plan in order to avoid the risks, the impact of negative and positive events on project costs, and prioritize the risks according to the probability of their occurrence. (11). Also, Kumar et al. reviewed a study entitled "Improving the management of medical equipment and communications affecting it using automation and effective communications" and the results showed improvement of management and prevention of wasting and stealing by implementing a management information system (12). In this regard, Madia Sen et al. have evaluated the soft systems in software design, pointing to guiding problem areas toward improvement using this model. This model has been mentioned as an interaction between the real world and the mental world (13).

One of the new approaches that emerged to introduce the system of human activities is the methodology of soft systems (14). In our country, with the introduction of the basics of a knowledge-based economy, discourse and missions related to the development and support of knowledge-based companies and the establishment of incubators in universities to expand, and support creative, innovative and entrepreneurial thinking in the academic community in the country and increase in production, the process of creating employment, wealth and prosperity in society have begun. (15). Until 2017, it was not possible to access information and updates on the activities and processes of those centers and the need to create a comprehensive management information collection system in this area is obvious. Given the infancy and dynamism of incubators in universities, this can be done using appropriate scientific foundations such as SSM. The soft systems methodology was first developed in the 1970s by Peter Checkland and his colleagues at the University of Lancaster, England. Soft systems methodology is used in any human situation that requires thinking about purposeful activity. In this method, the researcher and stakeholders are involved in the problem situation and try to take actions that lead to solving the problem and improving the research problem situation. In this methodology, the issue is not considered as a problem, but as an inappropriate process that must be corrected (16). According to the research conducted using Google Scholar search engine and other search engines, no documentary evidence of the use of this model in the design of management information collection systems was found. In the SSM model, special emphasis is placed

on identifying and involving the users in MIS design. Therefore, it can be expected that in this method, in addition to using user experiences in recognizing the status and challenges in the management of incubators, social realities in the system design and application are identified and concepts related to the current processes in the incubator and systems are formulated and defined to have a comprehensive mental concept model before designing, so that this structure can play a significant role in the design, construction, and implementation in the real world. Identifying the problem areas in the organization is possible with the participation of employees in the processes of the organization, guiding them to improve with their participation. By using the SSM model in the design of management systems, it can be said that coordination can be established between the real world of users and the mental world of system designers.

In this paper, the efficiency of using soft systems methodology as a conceptual model in the design of data collection systems of start-up organizations through the use of this method in the design and preparation and implementation of a comprehensive management system for incubator was investigated.

Methods

Seven implementation steps were considered for successful implementation of an SSM; they include:

1- Identification and analysis of challenging situations

2- Position expression by stakeholders and facilitators (political and social analysis)

3- Selection of system-related concepts

4- Summarization of the conceptual model in the form of a mental structure

5- Application of the structures in the real world

6- Practical analysis and making desirable changes

7- Implementation of change processes in the organization

Stages 1, 2, 5, 6, and 7 are performed in the real world in relation to the problem, and stages 3 and 4 are performed in the space of systemic thinking but in relation to the real world. The seven steps of the soft systems methodology model for this region, which include Types 1, 2 and 3 universities of medical sciences in terms of scope and activity were performed as follows:

Stage 1: Identification of challenging situations

In university incubators, the directors of these centers have the necessary authority to make decisions, and the position ("roles", "norms" and "values") is more or less defined according to the rules and regulations. In order to study the challenges in the organization as well as the problems ahead in designing and implementing a comprehensive management system to collect information from the incubator and companies affiliated to them by holding various face-to-face meetings with experts and officials of various management, IT, finance and technology units in Shiraz University of Medical Sciences and related universities in the region or through correspondence and questionnaires, we identified the most important challenges and finally the opinions were summarized and divided into two categories of general and specific challenges.

Stage 2: Position expression by stakeholders and facilitators (political and social analysis)

1- Identifying the people involved and key decision makers in the system design

In order to better identify and understand the position and feasibility of the success of the management system of data collection of incubators, first we identified the list of employers, executives, users and people involved in the issue and their organizational roles in relation to the system through face-to-face meetings with educational and research assistants, growth center managers, technology managers, and other key people; then, the demographic characteristics of the universities were determined, and finally, after summarizing, the role of each university in terms of being a real or legal beneficiary and the role and scope of influence in design, installation, deployment, evaluation, and use of the system was identified.

- Identifying local stakeholders and actors and analyzing the political and social system

Although managers and experts of the university and regional incubators are one of the most important stakeholders of the system, since the interactions of each center with internal and external organizations in each university and region are different, taking into account the current and future organizational position of technology and incubator in universities, the initial list of customers or stakeholders and local, regional and national actors of the system was prepared, and their expectations in three different areas of analysis, including self-intervention analysis, social analysis, and political analysis were collected and divided as follows:

- Self-intervention analysis: In order to perform self-intervention analysis and identify the employers, executives, owners, and individuals directly involved with the system, we made an attempt to identify the organizational roles of growth center managers as well as relevant officials in the universities. In

this regard, key individuals were divided into the following three categories:

1. Individuals and managers who had formed the intervention and had an employer role in the matter.

2. Real and legal persons who were the executors of the system and these who had the role of executor and user in this system.

3. Individuals and legal organizations that could play a role in establishing, evaluating and developing the system. These people can also be called system owners. Through field studies and libraries, the most important cultural features affecting the system were identified in a table. Employers, executives, owners, and people involved in the issue were also identified.

- Social analysis: In order to socially analyze the system, in designing such a system, different demographic characteristics of the universities in different provinces such as Bushehr, Hormozgan, Kohgiluyeh, Boyer-Ahmad, and Fars were collected and used to determine the level of access, data analysis, and development.
- Political analysis: Creating and accessing a comprehensive management system for data collection can affect the pillars of power between incubators and universities in the region. Therefore, by consulting the experts and discussions within the group with the officials of incubators and senior managers of the Ministry of Health and Medical Education, the required predictions were made to design the system and real and legal persons, and their status were determined.

Stage 3: Selecting system related concepts

Following the SSM steps and in order to make a connection between the data obtained from the previous steps, which further express the facts and expectations in the environment, and relate it to the necessary mental requirements, all the required specifications of a system were categorized in the form of predefined and selected models to design a comprehensive system. In this regard, CATWOE method was used to formulate the problem using key definitions. The components of the word CATWOE are as follows:

1. Customer: The list of agents, stakeholders, and users of the comprehensive system of incubators, which was prepared in the second phase of SSM implementation, was used as customers in the CATWOE checklist.

2. Actors: The list of participants and anyone who performed defined activities in incubators and companies located in them, which was prepared in the second phase of SSM implementation, was used as the initial list of actors in the CATWOE checklist.

3. Transformation (processing or converting the input information): In order to determine the process of converting the input to output in the system and determine what data should be entered into the system by the actors, we determined the list of current processes in the incubators and based on the type of each activity, the type of input data and the one responsible for entering that data were determined. Since it is necessary in the management system to collect information from the office automation and the data entry systems of incubators as a network, these items were also included in the method of determining the data conversion process. In addition, the types of different output formats required by managers and experts of incubators and senior officials of universities and other bodies were collected by universities, and after summarizing, they were finally approved.

4. World view: In the fourth stage, the universal or ultimate approach of the system was developed to make the conversion process meaningful. In other words, the main objectives in the design, production, and deployment of the system were explained, summarized in a table and approved.

5. Owners: In the fifth step of CATWOE, the owners of the system developed were identified. After reviewing the results of the second phase of the SSM and also by studying the results of field visits to the capabilities of the universities in the region to invest and host servers and provide the necessary physical infrastructure, software, hardware, manpower, and expertise to support and maintain the system and also, by studying the results of social and political analyses obtained from stage 2 with the opinion of other universities, Shiraz University of Medical Sciences was determined as the system owner and the main investor and supporter.

6. Environmental factors: During the various meetings held between the heads, managers and officials of the incubators of the member universities of the fifth region, environmental factors that could have a facilitating (positive) or deterrent (negative) effect on the system were identified and summarized in a table to be examined in later stages.

Stage 4: Summarizing the conceptual model in the form of mental structure

By holding various meetings with the plenipotentiary representatives of the universities and experts, the goals were first set and then prioritized. In this regard, meeting the basic needs of regional incubators in a structured and organized manner as the first priority, having capable managers and experts with desirable performance to develop

and support the companies located in incubators as the second priority and increasing targeted role-playing of the universities in the region, planning to implement a knowledge-based economy, quantitative and qualitative promotion of employment, entrepreneurship and wealth creation in the community were identified as the third priority.

Stages 5 and 6: Applying the intended structure in the real world and practical analysis and making the desired changes for the desired situation

At this stage, using the designed structures as well as the conceptual model developed in the previous stages, we examined their degree of adaptation to the real world, and various actions were performed as follows:

1. Questionnaires were developed using the proposed principles and according to the intended objectives and the opinion of relevant experts in accordance with the conditions and objectives of the project and then, according to the obtained statistical information, they were analyzed.

2. After preparing the system, Shiraz University of Medical Sciences was selected as a pilot university due to having 6 incubators, multiple fields of activity, and sufficient infrastructure and manpower. After this step, all member universities of the region were selected as users. Accordingly, by defining the incubators of those universities and their users in the system and the scope of access for them, this was also implemented. Then, under the supervision and guidance of the researcher and in order to plan and execute the schedule, during a period of time, the information of the incubators of the member universities of the region and the companies located in them was entered and different stages of the processes were performed by the researcher in order to finalize and solve the problems in the system. In addition, the absence of any errors in the operation of the system for the entire region was checked.

Stage 7: Implementing and evaluating organizational change processes

This step included finalizing the steps of designing, installing, implementing and using the system and implementing the steps of change processes and institutionalizing the changes resulting from using the system, and finally evaluating the actions taken based on the goals set. In the first stage, all actions and activities that helped to achieve the objectives of the design, installation, implementation and use of the system were controlled in accordance with the RFP and regulatory contracts and regulatory meetings with university representatives about the system. Then, structural changes in the organizational thinking of the incubators were examined based on the goals of the new management system. For the mentioned evaluations, the quality control method was used based on the principles of evaluation including Design Qualification (DQ), Installation Qualification (IQ), Operation Qualification (OQ) and Performance Qualification (PQ) (17-20) to achieve the goals of the system and management system.

Results

The results of the study of the challenges in the design and implementation of a comprehensive management system were collected and the information of incubators and companies located in them, which was finally approved by senior university officials, was divided into two categories of general and specific challenges. The instability of the management and organizational structures and manpower in the incubators of universities, which has created different managerial and executive cultures among the officials and their staff, is one of the most important public challenges that cause many problems and capabilities in performance development and management of incubators in universities. According to the SSM method, identifying and paying attention to individuals and legal entities is effective because having sufficient information and understanding their expectations and capabilities can significantly help the designers and executives in providing the necessary analysis such as self-intervention analysis, social analysis, and political analysis in the next stages. Since it is necessary to determine the actors and their scope of access to the system, In this regard, the range of access of actors in different units in the system was determined, so that they can play different activities in the system. In the Katowice method, it was found that the ultimate attitude to express the main goals of the system implementation should be developed by key people in the management system. In addition, the activities that must be done to achieve them were also identified and named as root activities. Table 1 shows the objectives of implementing the integrated management system of incubators and the root activities to achieve them.

The last parameter in determining the concepts related to the system based on the CATWOE checklist is identifying and examining the impact of environmental factors on the system activity in terms of facilitating (positive) or deterrent (negative) effects in the system that is listed in Table 2. As can be seen, such factors can be divided into two categories: human and infrastructural factors. In the meantime, we can emphasize the role of resistance of the staff

Table 1: Objectives of implementing the integrated management system of incubators and the necessary activities to achieve them

	Goals based on prioritization	Necessary activities to achieve the desired goals (root activities)
1	Objective 1: Meeting the basic needs of regional incubators in a structured and organized manner (first priority)	Gathering stakeholder feedback, training and culture building, obtaining licenses and credit and selecting the owner, identifying processes, preparing environmental factors, allocating cyberspace and admin
2	Objective 2: Having capable managers and experts with desirable performance to develop and support companies located in incubators (second priority)	Accuracy of information and speed of access to them, working with the management dashboard and increasing the speed of decision-making, the possibility of better interaction with external stakeholders and increasing the speed in introducing companies to take advantage of opportunities
3	Objective 3: Increasing the purposeful role of universities in the region, planning to implement a knowledge-based economy, quantitative and qualitative promotion of employment, entrepreneurship and wealth creation in society (third priority)	Increasing the number of companies located in the incubators and increasing targeted support for knowledge-based companies, increasing the participation of the faculty and students and improving the interaction between academia and industry, and increasing wealth production and employment in society

Table 2: Environmental factors affecting the activity of the system, including facilitators (positive) or deterrents (negative)

	Facilitating (positive)	Deterrent (negative)
Human Factors	Staff flexibility	Personnel resistance to change
	Personnel confidence	Lack of confidence
	Personnel justifiability	Lack of justification of personnel
	Cooperation of managers	Lack of cooperation of managers
	Up-to-date and managerial experience of officials	Lack of up-to-date and managerial experience of officials
Infrastructural factors	Cooperation of the contracting company	Non-cooperation of the contracting company
	Cooperation of companies located in the centers	Lack of cooperation of companies located in the centers
	Complete information from companies	Incomplete information from companies
	Providing the necessary credit	Lack of necessary credit
	University network speed	Network disruption
	Telecommunications	Communication disorder
	Experience and information of the project manager	Lack of experience and information of the project manager
	Holding training workshops	Insufficient training workshops
	Transparency of processes	Lack of transparency of processes
	Transparency of regulations and rules	Instability and lack of transparency in regulations

and senior managers against accepting changes in the system and the instability and lack of transparency of regulations.

Usually, changing the model of doing a job from traditional to electronic mode is confronted with resistance of the organization's personnel. For this reason, by holding several meetings, the colleagues were justified in this regard. Before implementing the personnel survey, the researcher asked them about the implementation of a comprehensive management system. 86% of the staff agreed with the implementation of the integrated system, which indicates a positive attitude of employees towards technological changes and mechanization of processes, through the use of the website.

Validation is a scientific approach based on knowledge and statistics that analyzes the current status and background of the applicant, and the credit score is calculated. The book of knowledge and technology management (18) contains valid management questionnaires in all fields and trends of management and is useful for managers and experts of organizations who want to improve and transform the organization and design data collection tools. At this stage, the statistical sample is specified. According to the definition, the sample is a number of people in the community whose traits are similar to those of the community, represent the community, and have homogeneity with people in the community. Attitudes measurement scales can vary in different types of validations. One of the most important scales for measuring attitudes is the Likert scale. In the Likert scale, a regular set of items has been compiled in a special order. In this study, the five-point Likert scale (strongly agree (5) agree (4) without comment (3) disagree (2) strongly disagree (1)) was considered and the indicators were designed in this regard.

Because the system was implemented all at once, some indicators (design, installation, implementation, and execution) could only be measured after implementation, and for others

(meeting the requirements and performance), they were also measurable and comparable before and after implementation of the system. For data analysis, SPSS and Excel were used. In general, to ensure the successful use of a management information system through the provision of a good system, it is necessary to make sure that the four steps of design, installation, and implementation, and assessment of needs and performance are well done and indicators related to the design, installation and implementation of a system should be such that the expectations of stakeholders and users are fully identified and prioritized to be used in different stages of implementation. In this regard, these indicators have been identified and the percentage of user comments after the run is shown in Table 3, based on the Likert scale.

In the requirements and performance indicators stage, the indicators were calculated and compared before and after implementation in order to comment on the implemented system. These indicators included creative work output, increasing communication and interaction between colleagues, increasing relationships between the centers and companies, increasing the accuracy and precision of the information, reducing duplicate data entry, reducing the workload, ensuring the user mental

Table 3: Indicators related to the design, installation and implementation phase and the percentage of user comments after the implementation based on the Likert scale

Indicators		Percentage of user comments from MIS implementation in incubators		
		Agree and completely agree	No comment	Disagree and completely disagree
Design	Easy connection to the system	%76	%12	%12
	Quick download of system related pages	%80	%8	%12
	Quick upload of required forms in the system	%72	%16	%12
	Appropriateness and adequacy of the fields in the company forms	%78	%12	%10
	Total percentage	%76.5	%12	%11.5
Installation	Connection to the system through any system and in any place	%91	%6	%3
	No need to install special software to connect to the system	%94	%3	%3
	Total percentage	%92.5	%4.5	%3
Operation	Increasing users' capabilities by holding training workshops during implementation	%86	%10	%4
	Increasing user confidence by implementing a comprehensive integrated management system for incubators	%86	%8	%6
	Adding SMS system to the system during implementation to inform the client and staff as needed	%79	%7	%14
	Total percentage	%83.6	%8.4	%8

Table 4: Equality test of the means of the two dependent groups for the indicators related to the meeting needs stage and post-implementation efficiency

Indicators	Stage	Number	Average user comments	Error	P value
1st indicator User response speed	Before running	50	4.08	0.075	0.011
	After running	50	4.28		
2nd indicator Repeating data entry	Before running	50	4.14	0.495	0.051
	After running	50	4.28		
3rd indicator Communication and interaction with colleagues	Before running	50	4.04	0.770	0.032
	After running	50	4.28		
4th indicator User mental satisfaction and system interaction experience	Before running	50	3.94	0.974	0.034
	After running	50	4.24		
5th indicator Workload	Before running	50	3.98	0.481	0.022
	After running	50	4.16		
6th indicator Accuracy and precision of information	Before running	50	3.88	0.109	0.022
	After running	50	4.14		
7th indicator Creative output of work	Before running	50	4.24	0.245	0.128
	After running	50	3.86		
8th indicator Relationships between incubators and companies	Before running	50	3.84	0.113	0.026
	After running	50	4.10		

satisfaction and interaction experience with the system. Accordingly, the P-value was determined using the equality test of the means of the two dependent groups (19) and the observations of each subject against each other. Table 4 shows these results.

Discussion

In the calculations, the highest percentage of the users' opinions about the indicators related to the design, installation, implementation, and execution stages were 76.5%, 92.5%, and 83.6%, respectively, for the items agree and strongly agree in the Likert scale that indicates the acceptability of the evaluation and meeting the expectations of stakeholders on how to design, install and implement a system related to the management information system of incubators. On the other hand, for the indicators related to the meeting needs and efficiency stage, the results of this comparison (before and after running) show that in the case of the index of increasing the speed of the user response, increasing communication and interaction with colleagues, increasing the accuracy and precision of data entry, increasing the relationship between incubators and companies, reducing repetitive data entry, reducing staff workload and user mental satisfaction, and the experience of interacting with the system, significant differences were observed (Sig.(2-tailed)<0.05). It seems that these seven indicators have improved, and the implementation of a comprehensive management information system has had a positive effect on the improvement of these indicators, but there was no significant difference in the index of increasing creative work output (Sig. (2-tailed)>0.05). It can be concluded that in this evaluation, the management information system has not affected this index and it seems that in the management dashboard system, the diversity of reports as well as the permission of experts to access such reports need to be reviewed. In general, it can be said that the SSM can be used as a suitable model for implementing and executing a management information system. In this regard, our findings are in line with the results obtained by Panagiotis Triulas (21) and Gason (22). There were some limitations in this research; for example, the managers' lack of knowledge about management science was one of the primary obstacles of this research too. We can refer to the social conditions prevailing in each organization and the culture of different people.

Suggestions

Soft systems methodology can be considered as a relatively new topic in management and the study of field and implementation areas of combined methodologies can be the subject of many future researches. The incubators of medical universities in the south of the country were selected as the subjects in this study. By implementing this model in other universities of medical sciences, it is possible to understand the similarity and difference of views and, consequently, the results of the research by comparing the results obtained from them and the results of this research. Also, the proposed model can be implemented in other parts of the university to make its advantages and limitations more obvious.

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