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Assessing the effectiveness of knowledge management using Analytic Network Process

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Abstract Knowledge management in higher education is a set of organizational processes that support creating and transferring the knowledge in these institutions and allows for achieving organizational and university objectives. Therefore, for the proper management of organizational knowledge, appropriate tools are needed to be able to be aware of the effectiveness of knowledge management in organizations. The study also has used integrated approach in the form of analytic network process techniques to calculate the level of the effectiveness of knowledge management and comparing the universities. In this technique, the dimensions of the balanced scorecard and knowledge cycle processes are considered as indicators. The data was collected by field study and through questionnaires distribution and paired comparisons between the University experts, and Super Decisions software also was used to analyze the data. The results of this study can be applied both in improving the effectiveness Universities' knowledge management, and developing the assessment model and comparison of effectiveness in the university sector.

Keyword: knowledge management, Measurement of effectiveness, Balanced Scorecard, Analytical network process.

1 Introduction

In today's competitive environment, organizations need to have a degree of knowledge assets significantly more than in the past. These features, being inimitable, rare, valuable and irreplaceable, along with the emergence of approaches and concepts such as Knowledge Management (KM), intellectual capital, intangible assets, and knowledge-oriented approach to the organization and increased researches of academicians and executive practitioners indicate the growing importance of knowledge resources in organizations [1].

Meanwhile, the higher education institutions are faced with many challenges such as rapid technological changes, systems expansions, diversification of demand, increasing the training costs and the need to adaption to the era of knowledge and information. One of the tools used to deal with this situation is knowledge management. Knowledge management in higher education is a series of organizational processes that supports the creation and transfer of knowledge in these institutions and allows for achieving organizational and academic

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objectives [25]. It should be noted that academic institutions as centers of production and dissemination of knowledge, require the implementation of knowledge management more than any other institutions. Although the universities themselves are repositories of knowledge, no sufficient attention has been paid to the intellectual capital and scientific resources produced by the academic community. To date, no control have been applied over the unwritten knowledge (knowledge in the mind), and also the domestically produced recorded information have rarely been collected seamlessly and managed within a systematic framework. This mismanagement caused that many valuable assets remain unknown and inaccessible forever, and many existing gaps still remain in force [9].

The main role of these institutions is knowledge management (both tacit and explicit knowledge) in order that they can enhance the knowledge performance toward the improvement and development of the community [8]. In fact, educational institutions need to identify their current situation to develop improvement programs in order to achieve the desired situation. If they cannot evaluate their level of knowledge, the knowledge management cycle remains incomplete, because it doesn't make any feedback so that reforms could be made in various components of knowledge management. Thus the need to assessing the effectiveness of knowledge management in organizations by experts and professionals is felt more than ever before and of special importance. Therefore, considering the mentioned need, in the present study, we seek to assess the effectiveness of knowledge management at universities.

In the current era of knowledge, organizations have found that in this era their life will not continue unless they have a strategy for the management and valuation of their knowledge [21]. For this reason, and in order to properly manage the organizational knowledge, appropriate means is needed. So that using it, one can be aware of knowledge management in an organization. This awareness of the situation of knowledge management in an organization helps the organization to properly identify weaknesses and deficiencies of its knowledge management in order to maintain or enhance competitive advantages [29]. But this topic in higher education institutions, especially universities, has long been considered, because the existential philosophy of these institutions is the production and dissemination of knowledge in society, and knowledge management of in these organizations always have been at the axis of their strategic planning. So as long as the universities don’t perform surveys in the field of their knowledge assets, knowledge management will lead to performance improvement and organizational development. In addition, the measurement of knowledge management is a complex subject; on one hand, this complexity is the result of the number of variables involved in this issue, and on the other hand, is due to the existence of verbal variables which adds uncertainty component into the decision making [29]. So, we can see that assessing the effectiveness of knowledge management is also a type of multi-criteria decision-making process, because these problems require the consideration of many factors being interpreted as assessment criteria. Hence, the application of existing methods of multi-criteria problems is appropriate for assessing the effectiveness of knowledge management. Therefore, in order to promote the level of knowledge management’s effectiveness in universities and increasing the awareness of authorities in this field, in addition to the application of widely used indicators and benchmarks for knowledge management's assessment, this paper has addressed the assessment and comparison of effectiveness of knowledge management in three universities the strengths of analytic network process in order to identify existing strengths and weaknesses and necessary planning should be done to improve it. In this study, the balanced scorecard dimensions are considered as indicators of the effectiveness assessment, and knowledge management performance index tools are considered as knowledge cycle

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processes. Therefore, to achieve the objectives, this study sought to answer the following research question:
- How is the significance level of knowledge management's effectiveness indices (balanced scorecard dimensions) at the universities?
- How is the significance level of knowledge cycle processes in each indicator of the knowledge management effectiveness at the universities?
- How much is the effectiveness level of knowledge management in the three universities?

2 Research Background

Today, knowledge management is considered as one of the newest and most key issues in the management of higher education, while this issue is not a new phenomenon. In fact, the knowledge management has existed since hundred years ago, when craftsmen and practitioners in various jobs transferred their professional experience to their children and pupils [23]. Knowledge management is the way in which organizations manage their knowledge assets, and includes the collection, storage, transfer, use, update, and create the knowledge. Karkulyan et al. [13] also believe that knowledge management is an approach to create an organization the members of which can gain, share and create knowledge it or apply it for its decision making activities.

In most resources, knowledge management has four main parts: storage, retrieval, transfer, and application of knowledge, and always the fifth step, which can be knowledge measurement, is missing in the main stages of knowledge management, while its presence is essential for the successful implementation of other processes of knowledge management [11]. The main challenge of knowledge management is the more and better conversion of tacit knowledge into explicit knowledge. Experience has shown that in recent years, organizations have spent lot of money in the field of knowledge management. The calculation of this investment is easy, but accurate and correct calculation of its return on investment is very difficult [15]. If we want to assess the success of knowledge management, we must be able to assess the knowledge. Knowledge assessment doesn't mean its monetary estimation; it means that we determine whether or not the knowledge objectives have been achieved. If organizations fail to measure their knowledge, the knowledge cycle remains incomplete. This is why there is no feedback so that based on that, the possible modifications be made in several fundamental elements of knowledge management. Due to this, the definition of alternative indicators to determine the success of the knowledge management system is among the challenges of knowledge management [22].

The meaning of knowledge management effectiveness is to meet the objectives of knowledge management and satisfaction with it [26]. But the assessment of knowledge management based on business interests is difficult, because knowledge management tools are not clearly defined yet. Chen and Chen [3] divided knowledge management performance assessment tools into two categories: quantitative and qualitative. Qualitative measures include improving staff skills, product quality, business processes and customer (seller) relations, while the quantitative measures include reducing operational costs, improving productivity and increasing the profits. Chua and Gho [5] defined four elements of organizational processes, including the activities of knowledge, knowledge assets, the impact on organizational activities and commercial objectives.

On the other hand, the implementation of knowledge management requires the application of methods that can evaluate the contribution of knowledge management in

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realizing the strategy and knowledge management plan based on mentioned indicators. However, these tools focus on the organization, not the knowledge management itself. Therefore, knowledge management needs appropriate techniques, technologies and tools for effective implementation [11]. So, according to the above description and review of assessment tools, it can be found that assessing the effectiveness of knowledge management is a type of multi criteria decision making problems. These issues need to consider many different factors that can be interpreted as evaluation criteria. As a result, the use of current methods for multiple criteria problems is appropriate to assess the effectiveness of knowledge management.

While many studies have been done on the evaluation and assessment of knowledge management, few academic studies have been seen with the use of multi-criteria techniques. Chen et al. [4] provided in a study an approach for measuring the performance of knowledge management of university from a competing view. This approach has combined the analytic network process (which is a theory for multi criteria decision making) with balanced scorecard, then is matched with indicators for measuring the performance of knowledge management. Huan et al. [10] using the technique of analytic network process proposed a method for the comparison between the knowledge management performance of a company with its main competitors based on the processes of knowledge management. After reviewing the literature and receiving experts' opinions through in-depth interviews and reviewing them, Nahavandi et al. [20] in a study extracted the measures that influence the effectiveness of knowledge management in research centers. In this study, data analyzed based on the developed fuzzy analytic hierarchy process as a multi-criteria decision-making process. Mousa Khani and Nadi [19] prioritized the performance evaluation indices of knowledge management system using analytic hierarchy process, and then evaluated the performance of knowledge management system based on Balanced Scorecard using fuzzy comprehensive evaluation method. Shirouyehzad et al. [28] did a research aimed at prioritizing companies using the knowledge management process. By reviewing the research literature, they identified a general knowledge model including four processes of knowledge creation, storage, sharing, and application and used them to prioritize the car manufacturing companies. To do so, they utilized the fuzzy TOPSIS technique. The results of the study show that knowledge storage and knowledge creation are more effective than the other factors. To evaluate the function of KM in organizations, Lyu et al. [18] presented a simplified and applicable model based on the balanced scorecard approach. Subsequently, they made use of fuzzy comprehensive evaluation to evaluate the effectiveness and applicability of the proposed model. The results indicated that the proposed model is advantageous for evaluating the function of KM. Centobelli et al. [2] presented a 3D fuzzy decision support system with the aim of coordinating the organizational knowledge with KMSs to enhance the effectiveness and efficacy of the function. The proposed system was tested in the small and medium enterprises (SMEs) operating in the high-tech industries. The research results showed that this system can help the managers to evaluate and identify the KM processes and increase the effectiveness and efficacy by adopting their organization with the KMS.

In this paper, based on the expressed literature and existing models, the tools and techniques that Chen et al. [4] have presented are used as the initial model. One of the features of this model that makes it better than other models is that it simultaneously applies two important and useful tools: Balanced scorecard and knowledge management processes. One of the methods of knowledge management assessment is the balanced scorecard approach. In fact, the scorecard approach is a method to supplement traditional financial measures with three factors of implicit and intangible success, including human capital (knowledge and

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skills of humans), structural capital (intertwined knowledge within the organization's processes and systems) and customer capital (customer relationships) [12]. A major advantage of this approach knowledge management is that it expresses a close relationship between organizational learning and other measurements [11] and its use directly connects learning from the knowledge management to the performance of organization's performance, which in turn is linked with the organization's overall performance [27]. In addition, the knowledge management processes are derived from knowledge management performance indicator tools, which Lee et al. [17] presented to evaluate the performance of an organization in the implementation of knowledge management. Knowledge cycle includes knowledge creation processes, collection of knowledge, sharing of knowledge, application of knowledge and internalization of knowledge. In this context, references [7, 14, 16] will also be useful. The research model is shown in Figure 1.

3 Research methodology

This research is descriptive survey and of applied type. The data collection for this research has been done as field data collection. In this method, due to multiple indices and relationships between them, analytic network process technique has been used for comparative assessment of the knowledge management effectiveness. Analytic network process is one of the multi criteria decision making techniques which was offered by Saati for providing a solution for those multi criteria decision making problems in which mutual correlations and relations are present among decision making levels (objective, decision making criteria and their sub-criteria, options). Analytic network process is the expansion of hierarchical programming technique [24].

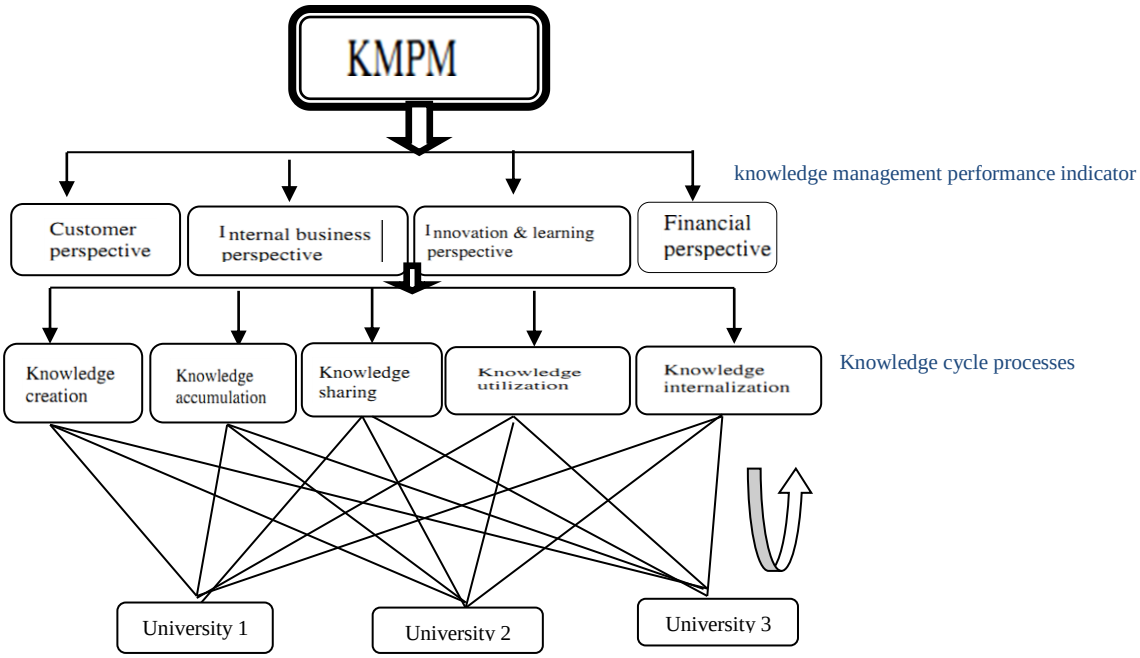


Fig. 1 Research model

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Hierarchical technique was presented in 1980 by Saati to solve multi-criteria decision making problems. The basic assumption of this technique is that the relationships between decision-making levels are one-way and hierarchical. It means that each decision making level depends only on its upper level. But because of the internal and external dependence of the interactions and relationships between elements of the clusters in decision making levels we cannot consider many multi-criteria decision making problems as hierarchical. Thus, analytic network process technique with a comprehensive framework can take into account all interactions and relationships between levels of decision-making that form a network structure. To illustrate the interactions and dependencies between decision-making levels, determine the relative importance of the criteria and prioritize the options of the problem, the super matrix was used [6].

Due to the use of analytic network process technique, the questionnaire includes questions in the form of paired comparisons, which was placed at the disposal of managers and professors as experts. In addition, in order to compare the preference of elements in each level the Saati spectrum and to assess the compatibility of paired comparisons matrices the Saati method were used, according to which, if the incompatibility rate is less than 0.1, the answers are compatible and subsequent calculations are applied on it, otherwise the questionnaire will be returned to the expert in order to receive consistent answers. The compatibility of the ultimate matrix of this study was also approved. Calculations of data analysis have been done in Super Decisions software. Computational steps of this research towards achieving the research objective are as follows:

First step The formation of model and structuring the problem.

Second step The calculation of priority vectors of paired comparisons at each level
-Priority vector of four indices of knowledge management effectiveness (balanced scorecard dimensions) (P_j)
-Priority vector of knowledge cycle processes (A_{kj})
-Priority vector of faculties (S_{ikj})

Third step Formation and calculation of super matrix for external dependence between levels
-Priority vector of knowledge cycle processes at the each universities (B_{kj})

Forth step Calculation of desirability index
-Desirability index universities (i) is calculated as follows:

$$Di = \sum_{j=1}^{j} \sum_{k=1}^{k} P_j \times A_{kj} \times B_{kj} \times S_{ikj}$$

P_j: relative importance weight of KM performance indicator *j*.
A_{kj}: relative importance weight of the component *k* of KCP on the KM performance indicator *j*.
B_{kj}: stabilized relative importance weight of the component k of KCP on the KM performance indicator *j*.
S_{ikj}: relative performance score of organization *i* on the component *k* of KCP for the KM performance indicator *j*.
K : index set of component *k* of KCP and *J* is the index set of KM performance indicator *j*.

4 Research findings

Using the network structure of the conceptual model and following the computational steps of the research mentioned above, the utility index (D_i) universities is calculated according to the criteria, as seen in three final columns of Table 1.

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Table1 Desirability index calculation for KMPM

Indicators	Pj	process	Akj	Bkj	Sikh	Sikb	Sike	University 1	University 2	University 3
	0.203	KC	0.1548	0.3008	0.494	0.3012	0.2046	0.004	0.002	0.001
	0.203	KA	0.0704	0.0712	0.3880	0.2332	0.3784	0.0004	0.0002	0.0003
CP	0.203	KS	0.1525	0.1034	0.3682	0.4644	0.1673	0.001	0.001	0.0005
	0.203	KU	0.3056	0.3511	0.3327	0.358	0.3092	0.007	0.007	0.006
	0.203	KI	0.3165	0.1733	0.3214	0.3	0.3775	0.003	0.03	0.004
	0.293	KC	0.1332	0.38	0.3489	0.5328	0.1182	0.005	0.007	0.001
	0.293	KA	0.0570	0.0883	0.3497	0.3301	0.3201	0.0005	0.0004	0.0004
IBP	0.293	KS	0.1579	0.1372	0.322	0.3332	0.3447	0.002	0.002	0.002
	0.293	KU	0.4229	0.1961	0.2911	0.3773	0.3314	0.007	0.009	0.008
	0.293	KI	0.229	0.1983	0.3546	0.228	0.362	0.004	0.003	0.004
	0.246	KC	0.2451	0.4243	0.3306	0.4562	0.213	0.008	0.011	0.005
	0.246	KA	0.0558	0.0848	0.2103	0.2359	0.5537	0.0002	0.0002	0.0006
I&LP	0.246	KS	0.135	0.1056	0.1857	0.361	0.4532	0.0006	0.001	0.001
	0.246	KU	0.413	0.1943	0.2907	0.338	0.3711	0.005	0.006	0.007
	0.246	KI	0.1508	0.1908	0.3904	0.35	0.2592	0.002	0.002	0001
	0.257	KC	0.2488	0.3084	0.2958	0.5	0.203	0.005	0.009	0.004
	0.257	KA	0.0822	0.0863	03949	0.275	0.329	0.0007	0.0005	0.0006
FP	0.257	KS	0.1844	0.1393	0.2103	0.406	0.383	0.001	0.002	0.002
	0.257	KU	0.3496	0.2223	0.2504	0.592	0.157	0.005	0.011	0.003
	0.257	KI	0.1384	0.2422	0.3737	0.402	0.2	0.003	0.003	0.001
Di								**0.0706**	**0.0901**	**0.0599**

As mentioned in the first research question, in this study, the balanced scorecard dimensions were considered as indicators of the effectiveness of knowledge management, and the importance degree of these indices in the universities according to column (P_j) in Table 1 are respectively: the internal processes dimension (0.293), Financial dimension (0.257), the innovation and learning dimension (0.246), and the customer dimension (0.203). It can be concluded that from the experts' point of view, the internal processes dimension has the utmost importance to the effectiveness of knowledge management in universities, following by financial dimension. Furthermore, the customer dimension has the lowest priority to the effectiveness of the system.

In addition, according to the second question of this research, knowledge cycle processes are considered as sub-criteria of the indicators of knowledge management effectiveness. It means that the status of the processes is investigated in each index. According to the results of the column (A_{kj}) in Table 1, it can be said that from the experts' point of view, the process of knowledge creation and application of effectiveness indicators is very important and is considered as an essential process. This suggests that the use of knowledge is very important to the effectiveness of knowledge management. In addition, the respective importances of other processes are as: internalization, sharing, and storage of knowledge.

Finally, to answer the third research question we can rate and compare faculties based on the effectiveness and processes of knowledge management using a desirability index (which is the knowledge management overall weighted index for each faulty). Final results of this study can be seen in Table 2.

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Table 2 KMPM analysis through five KCP components.

	University 1	University 2	University 3
Knowledge creation	0.0131	0.0323	0.0241
Knowledge accumulation	0.0021	0.0015	0.0018
Knowledge sharing	0.0061	0.0075	0.0052
Knowledge utilization	0.0252	0.0355	0.0251
Knowledge internalization	0.0125	0.0131	0.0142
KMOWI	0.0559	0.0901	0.0706
Normalized values for KMOWI	0.2717	0.4083	0.3199
Rank	3	1	2

According to the table above, the results indicate that in the total of four indicators of the knowledge management effectiveness, there is a considerable difference between the university 2 and the two other universities in terms of process. This is despite the fact that the storage processes of the three universities are at a very low level, and university 1 has a slight advantage over the others. In knowledge sharing, university 2 and university 1 are better than university 3. But in the application process, university 2 is superior to the other two universities. Finally, the ranking of universities in terms of internalization process is as follows: university 3, university 2, and university 1.

It can be seen that the final score between the universities in terms of the indicators of knowledge management effectiveness and knowledge cycle processes, university 2 have greater effectiveness in comparison with the other two universities. But according to the knowledge management overall weighted index, universities are relatively weak in terms of effectiveness and university officials should devote special attention to this matter in order to improve and enhance the effectiveness of knowledge management.

5 Conclusion and recommendations

One of the important tasks of knowledge management is knowledge assessment and it is considered as a tool to assist managers in understanding the extent of improvement of knowledge management. This assessment is important especially because it provides the ground for promotion and development of the knowledge. In fact, if organizations cannot assess their level of knowledge, the knowledge management cycle remains incomplete, because it does not cause any feedback so that necessary modifications can be made in different components of knowledge management.

In this study, in order to evaluate the effectiveness of knowledge management in universities an integrated approach was used in the form of analytic network process. In addition, in this model, balanced scorecard dimensions and knowledge cycle processes are considered as indicators of the effectiveness of knowledge management, based on which the universities were compared and rated. According to the results, internal processes dimensions among the indicators, and application and creation of knowledge among the knowledge cycle processes are more important. Finally, in terms of the effectiveness of knowledge management, university 2 is better than university 3 and university 1.

Also, according to the results of the status of knowledge processes it can be said that this process is the same in each of these universities. It is therefore suggested to universities that in order to compensate for their weaknesses, they operate through improving the knowledge cycle processes, this means that not only the training opportunities and degree of

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organizational learning should be enhanced, but also the application of databases and systematic management of knowledge storage should be improved. In addition, the success of knowledge management requires the motivation, willingness and ability of individuals to share their knowledge and to use others' knowledge, and university officials should consider this important point in the creation of appropriate culture.

Given that in the literature on knowledge management, various criteria, tools, and models are used for assessment, it is clear that each model has its own perspective of the assessment. But it is certainly possible to improve the assessment by using and comparing other models, indices, and even techniques of data envelopment analysis, TOPSIS, grey system theory and fuzzy theory.

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