Knowledge-Work Breakdown Method: A Pro-active Lessons Learned Management

Yasha Afshar-Jalili, Nasrin Sadeghi, Samareh Fakhimi, and Yokabed Beikkhakhian

***Abstract*—Businesses around the world are experiencing the transition from information age to knowledge age. Project-oriented organizations have learned that their success depends on their capability to learn from their past experiences. By using Lessons Learned Management (LLM) they would be able to apply their new findings to their future projects. But when a project is in a much larger scale in size and scope, this modern managerial approach seems a lot more complicated and somewhat impractical. For reduction of environmental complexity, organizations need a robust and applicable methodology for managing the lessons learned.**

This paper introduces Knowledge-Work Breakdown Method (KWBM) which is designed based on reviewing LL collective approaches to utilize lessons learned management more effectively and pro-actively. The results of a longitudinal case study show the success of this model in practice. By using KWBM, Output and outcome measures in most systems (in LLM context), have considerably improved. This paper investigates the concept, the steps and the results in handy details.

***Index Terms*— KWBM, KBS, KWB Matrix, Lessons Learned Management, Project Knowledge Officer (PKO)**

I. Introduction

Knowledge acquisition can be the bottleneck in developing a knowledge-base, which is essential in providing access to the experiences gained in any project[1][2][3]. Lessons learned (LL) are part of knowledge gained from experiences during a project and in the post mortem phase. It was initially conceived of guidelines, checklists or tips of what went right or wrong in every event worth mentioning, in projects' activities.

According to the 4th edition of PMBOK®, LL is an important part of project management. LL management is a simple and clear activity in a very small project. When a project's size increases in time, cost and work scope, all the simple tasks become more complex. In such conditions, LL management turns into an elaborate process. Despite all the relevant research in how to connect, collect and reuse LL, the lack of robust methodology is felt by a lot of project managers who are about to initiate another project.

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In this article, a systematic approach is presented which is deployed in a project-oriented organization, and has a great influence on forming a project knowledge-base as the result. KWBM is proved to be a particularly right solution for organizations with large, lengthy projects that are repeated again and again.

II. Review the Lessons Learned Approaches

Many military, commercial, and government organizations in developed and developing countries have deployed Lessons Learned Management Systems (LLMS) in order to provide access to results and outcome which were processed and validated, regarding various activities within their projects which could be reused in their other similar projects or training new project team members [4]. The underlying motivation is to help attain an organization's goals, regardless of their type and therefore any outcome that bears such depiction should be submitted and validated and made accessible for further use.

There are all kind of outcomes which can be counted as lessons learned, mainly the findings of first hand experiences of the executors and stakeholders of a project. The experience may be positive, as in a successful test or mission, or negative as in a mishap or failure. The important factor is how as a whole the experience is looked at and documented. The experience gained can be valuable to others, if it can have an impact on operations and provides a realizable solution for the problem or the obstacle that may not necessarily be circumstantial or onetime event. It should be factually and technically correct; and applicable in that it identifies a specific design, process, or decision that reduces or eliminates the potential for failures and mishaps, or reinforces a positive result [5].

Two different approaches exist; passive and active collection [4]. In passive collection there is usually a designed form that helps the applicant to structure their thought in order to document their experience in an orderly fashion, but the applicant decides when and regarding which case they should report by filling in that particular form. In active approach lessons are collected after each activity and the applicant knows what area of their knowledge is required regarding that activity and the scope of the experience is clear since it is connected to their latest activity.

III. Overview of the KWBM

Knowledge-Work Breakdown Method (KWBM) is an approach to manage lessons learned (LL) through projects. This method begins by designing the appropriate project work breakdown structure (WBS) and knowledge breakdown structure (KBS). After that, the time dimension is added to the cross action matrix of WBS and KBS which is called KWB Matrix. The essence of this approach is based on the both passive and active knowledge collections which led to design the systematic and pro-active LL collection during the project's activities. The Fig.1 shows KWBM steps:

Fig. 1. KWBM steps.

IV. Description of KWBM steps

A. *Design of Work Breakdown Structure (WBS)*

Project planning is one of the most important steps in effective project management. The main goal of project planning is to develop the project work plan, considering various crucial aspects. The project work plan could be used to predict the situation of project during its lifecycle, and enables the control of its progress trend [6].

Two reputable methodologies are mostly used to mange projects; PMBOK 1 and PRINCE 2. In both methods the importance of work plan is emphasized. WBS as a main part of work plan is a generic term for a hierarchy of stages of a project. However, in PRINCE method such a hierarchical diagram is called a product breakdown structure (PBS). In both methodologies, work plan shows the scope of the project that should be performed to achieve the deliverables of the project [7]. The degree to which the WBS needs to be broken down will be decided by the project manager.

B. *Design of Knowledge Breakdown Structure (KBS)*

KBS shows the required knowledge which is needed for deploying project's activities. Same as WBS, the broken degree depends on the decision of project knowledge officer (PKO) who is responsible for managing knowledge during the project activities.

For designing KBS, an effective methodology is needed. During the literature review regarding knowledge maps, knowledge modeling and knowledge trees, the model known as DRDC 3 Valcartier [8] was chosen as the basic methodology to design KBS in this article. Although, this methodology is used for knowledge modeling, it can be a proper base for developing KBS. This model is illustrated in Fig.2.

The KBS design methodology contains four layers as it is presented in Fig. 1. The inner layer "Approaches" refers to the fundamentals of designing KBS. Approaches will present essence of the KBS components. The next layer is called "Steps" which refers to the steps taken during the KBS design.

Third layer represents "Phases" of designing KBS that includes planning, structuring, validating and using, and the upper layer that is called "Reference Models", which ensure the reliability of the resulted KBS.

When a KBS is designed, some underlying principles must be kept in mind. Accuracy, relevancy, usability and reliability

1Project Management Body Of Knowledge (PMBOK) which is provided by PMI
2 PRoject IN Controlled Environment (PRINCE)
3 Defense Research and Development Canada

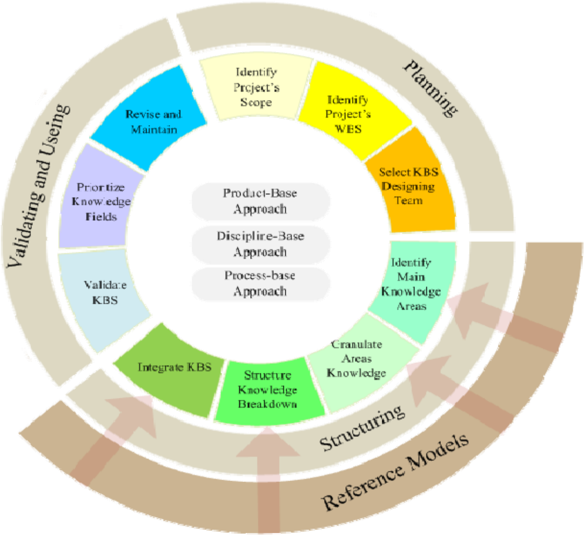

Fig. 2. Knowledge Breakdown Structure design methodology.

are all essential factors that contribute to the value of the KBS. Most importantly, the map must be accurate. For instance, the knowledge breakdown and its structure must be represented according to the project and its scope. Relevancy is another key principle to assess the value of the KBS. The breakdown and knowledge fields must be helpful to users in performing their tasks. Usability of KBS represents another underlying factor, worth mentioning. KBS must be uncluttered and readable. It must be easy for users to navigate and browse through it to find the knowledge they seek. The last important factor is reliability that shows the validity of KBS. To gain reliability, reference models such as APQC and SAP can be very useful.

C. *Forming KWB Matrix*

KWB Matrix is the cross-action matrix which is used in KWBM as a robust tool for managing learning events during executing the project in three levels; before, in and after action learning. The columns of this matrix are presented by KBS of the project in an acceptable layer, and the WBS is shown by the rows. Each crossed cell of this matrix illustrates the specific knowledge which is needed to execute the related activity in the project. The relation of WBS, KBS and project's schedule shows which knowledge areas are acquired for which activities and the time they have occurred. Fig. 3 is illustrated this concept.

D. *Lessons learned collection process (LLCP)*

LLCP starts with a learning event and continues through with two approaches; passive and active (Fig. 3). In passive approach, learning events are recognized by organizational members (knowledge workers) and are submitted voluntarily.

So this approach depends on how much they are tempted to share their knowledge. Therefore, this approach is really uncontrollable and unpredictable. Active approach can be used as a supplementary approach for covering the short comings of passive approach. In active approach project knowledge officer (PKO) and his team recognize the learning events by communicating with project's senior knowledge workers responsible for implementing the project's activities. KWB Matrix is a useful tool in PKOs hands to manage time and knowledge areas for recognizing learning events.

Actually, using both of these approaches that are introduced in this article as "pro-active approach" has a dramatic result in practice.

		Knowledge 01				Knowledge 02				
		K011	K012	K013	K014	K021	K022	K023	K024	K025
Work 01	W011			☑	☑					
	W012	☑					☑			☑
	W013	☑	☑							
	W014					☑	☑	☑	☑	☑
	W015	☑							☑	
Work 02	W021								☑	
	W022				☑					
	W023					☑	☑			

Fig. 3. KWB Matrix.

After submitting LL, the next activity is verification. Domain experts are responsible to verify the quality of submitted LL. They give the needed feedback to the knowledge workers about the content and quality of submitted lessons. This feedback cycle improves the quality and effectiveness of the lessons. Fig. 4 demonstrated this process workflow.

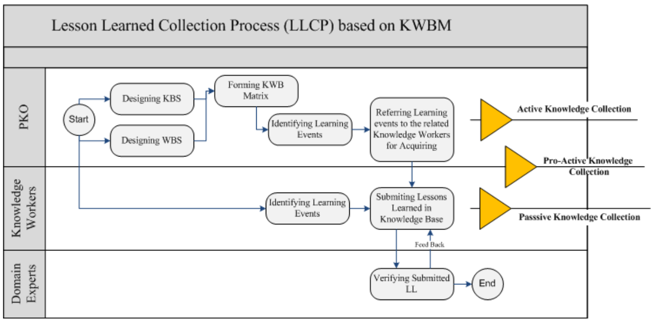

Fig. 4. Lesson learned collection process map.

E. *Learning from Submitted Lessons Learned*

In this step, all the project events that acquired knowledge are managed by PKO team for during and after action learning in current project, and also for before learning in future projects.

V. A Case Study

A. *Introduction of the Project (Scope, Scale, etc)*

Based on the world energy outlook 2009 which is reported by International Energy Agency (IEA), South Pars is a shared natural gas condensate field between Iran and Qatar which is located in Persian Gulf. According to the IEA report, the field holds an estimated 50.97 trillion cubic meters (1800 trillion cubic feet) of in-situ gas and some 50 billion barrels of condensated gas. This field is the largest gas field in the world.

National Iranian Oil Company (NIOC) is planning to develop the field in 24 to 30 phases. Each of the development phases is estimated to need on the average, around 2 billion USD of investment capital. Phases 17th and 18th were assigned to the consortium of Oil Industrial Engineering and Construction Company (OIEC), Iran Offshore Engineering and Construction (IOEC) and Iranian Development and Revolution Organization (IDRO). These phases will produce 2 billion cubic feet (57,000,000 m3) per day of natural gas, 75 MMcf/d of ethane, 80,000 barrels per day of condensate, 3000 tons of LPG per day plus 400 tons of sulfur per day. According to the project plan, Phases 17 & 18th will be completed by March 2012.

The facilities which are constructed in this project are developed on the basis of supplying treated lean gas to the domestic gas network and ethane gas to the nearby petrochemical complex at the required specifications while maximizing liquid recovery as C3/C4 LPG and stabilized hydrocarbon condensate for export. According to the scope of this project and its financial transactions, it could be categorized as a mega project.

B. *Using KWBM in a Mega Project*

For clarifying KWBM, some complicated steps like WBS design, KBS design and forming KWB Matrix are described in a real case in this paper.

1) *Designing WBS of the project*

WBS of the South Pars development project is marked confidential and cannot be used not given in this article. Therefore, just a general version of WBS is illustrated as follows.

This WBS can be broken into lower layers to become more useful, but it's sufficient for this article. According to Fig. 5, the scope of this project included survey, design, engineering, procurement, supply, installation, transportation, fabrication, construction, pre-commissioning, commissioning, start-up and performance testing.

2) *Designing KBS of the project*

According to the method that is presented in Fig. 1, first WBS of the project which is provided in previous section, should be reviewed.

For deploying next step of KBS designing, twelve members of PKO team were chosen based on the project structure. Strategic thinking, understanding related processes and interest in changing matters were critical factors for selecting KBS design team. For extracting main knowledge areas several two to three hours focus sessions [9] were held by the reputable domain experts. Consequently, four main knowledge areas were identified as first knowledge layer by the domain experts agreement; Project management (PM), engineering, procurement and construction.

In next step, main knowledge areas were granulated to maximum of three layers. The results were structured, integrated and validated through convergent interviewing technique [10]. Eventually, the designed KBS was prioritized by some measures. These measures are strategic alignment, repeatability and exclusiveness of the knowledge. The highest priority is colored by red and the lowest one is colored by green. The engineering part is illustrated in Fig. 5 as a practical sample. This KBS, depicted in figure 5, can be granulated to the lower layer depending on the decision of PKO for more effectiveness.

3) *Forming KWB matrix*

Based on LLCP which is illustrated in figure 3, forming KWB Matrix is the next step. For forming KWB Matrix of South Pars project, the supposed WBS is crossed with engineering section of KBS. The related cells are marked to show which activity will be deployed by which knowledge.

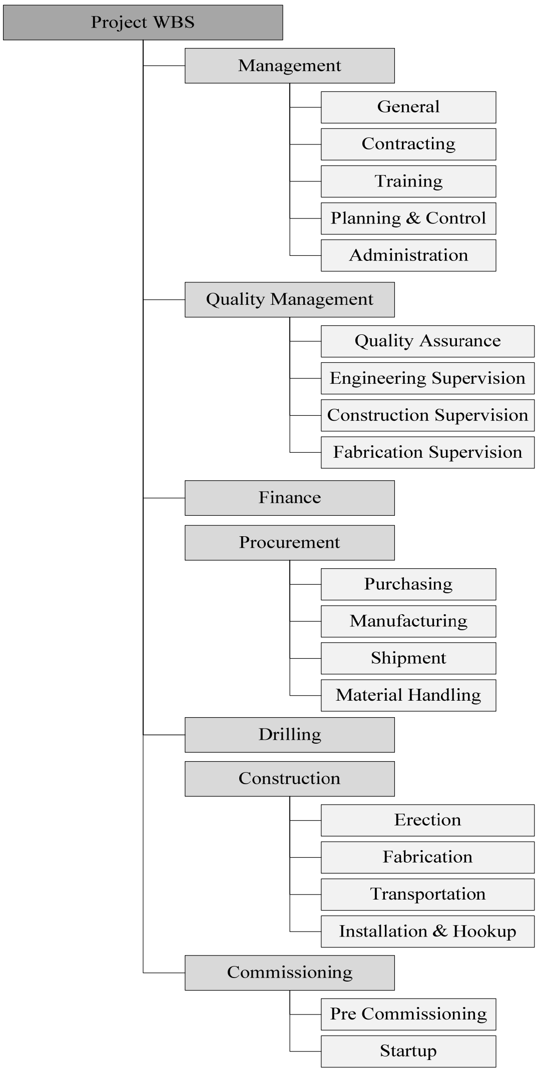

Fig. 5. Lesson WBS of the project.

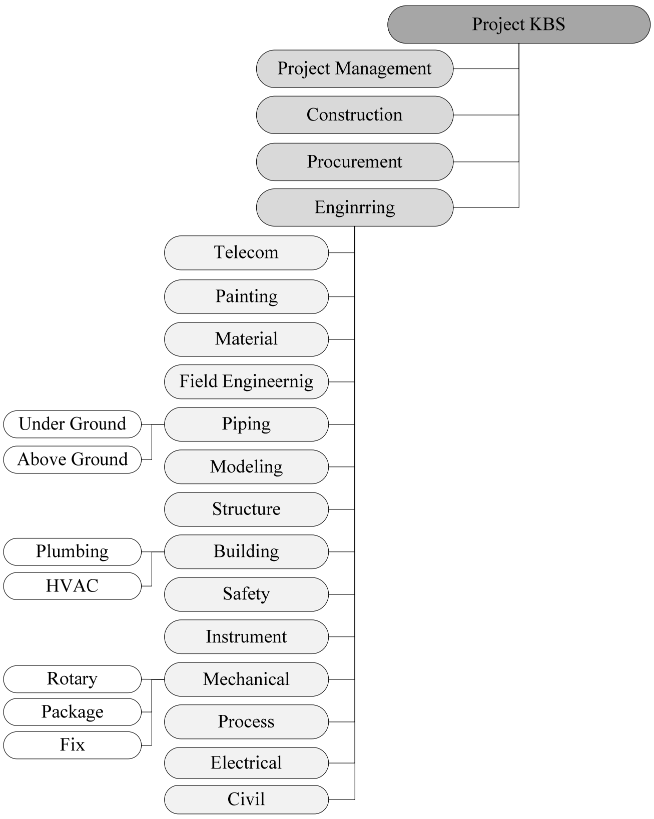

Fig. 6. Sample KBS part of the project.

The following table is a crossed-action matrix of the South Pars general WBS and its engineering section KBS.

As a sample, in Table I, mechanical fix knowledge is needed to operate training, quality assurance, engineering supervision, purchasing, manufacturing, erection, fabrication, installation & hookup, pre-commissioning and startup activities.

In next step KPO have to generate LL abstracting time schedule. As it illustrated in Table II, this schedule is resulted by crossing KBS and the project Gantt chart. Depends on which knowledge is used in which activity, LL abstracting time sheet will be generated. As a sample, mechanical fix engineering will be used as knowledge in erection and fabrication. According to the project Gantt chart these two activities will be accomplished by 30th of November and 30th of May, respectively. By this information, KPO expects that related LL will be submitted on the predicted time schedules. If no LL submitted in Knowledge Base, KPO will trace submission process more actively until the pursued knowledge is gained. Through this approach, the KPO will ensure that all critical LLs are submitted at the end of each activity. It is clear if KBS and WBS were broken in the lowest layer, the usefulness and accuracy of this approach will increased dramatically.

C. Results of Using KWBM

1) Performing measures

KM metrics should be extensively correlated to as many factors influencing the results as possible. Since there are many forces within an organization affecting people's learning, sharing, and efficiency, it is difficult to separate the effects of the KM processes from other processes. The KM measures should be used as a body of evidence to support analysis and decision making. As much as possible, the KM measures should be related to, the same as existing measures in the organization that are used to monitor the success of performing mission objectives.

Performance measures should be designed and implemented to reflect organizational goals and objectives. KM is a strategic business process that enables other critical business processes. Therefore, it is important to focus measures (and the entire initiative) on factors that affect the ability to achieve strategic objectives.

Based on report of "metrics guide for knowledge management" that was published by Department of Navy-USA in 2001 [11], performance measures can be categorized in tree types as follow:

- **Outcome measures** which determine the impact of the KM project on the organization and help determine if the knowledge base and knowledge transfer process are working to create a more effective organization.
- **Output measures** that measure direct process output for users and give a picture of the extent to which personal are drawn to and actually using the knowledge system.
- **System measures** which related the performance of the supporting information technologies to the KM initiative (such as LL management).

After holding three focus group sessions by KM experts, eventually, 14 measures and its manual for measurement is attained. These measures are listed in Table III.

2) *Data collection based on abstracted measures*

Required data is collected before (based on previous LL management system which has been used before) and after implementation of the KWBM through the project. Extracted results are compared within the Table 3 which includes the chosen measures. All the data is gathered in period of six months of using each approach; previous LL management system and the new KWBM. Fig. 7, 8 and 9 show the result for these comparisons.

In this regard, the first type of measures is called system measures. Results show (Fig. 7) that KWBM could improve all the system measures. KWBM implementation leads to rising of the number of system users, who submitted LL, number of downloads and contribution rates. In next part, all reasons of this improvement are described.

TABLE I: THE ARRANGEMENT OF CHANNELS

Knowledge Breakdown Structure (KBS) – Engineering		Management	General	Contracting	Training	Planning & Control	Administration	Quality Management	Quality Assurance	Engineering Suprv.	Construction Suprv.	Fabrication Suprv.	Financial	Procurement	Purchasing	Manufacturing	Shipment	Material Handling	Drilling	Construction	Erection	Fabrication	Transportation	Installation & Hookup	Commissioning	Pre-commissioning	Startup
Telecom					X				X	X					X	X					X			X		X	X
Painting									X	X					X												
Material									X	X					X												
Field Engineering									X	X	X	X									X	X		X			
Piping	Under ground								X	X					X												
Piping	Above ground								X	X					X												
Modeling									X	X																	
Structure									X	X					X	X											
Architectural	Building								X	X					X												
Architectural	HVAC & Plumbing				X				X	X					X												
Safety									X	X					X	X					X			X			
Instrument					X				X	X					X	X					X			X		X	X
Mechanical	Rotary				X				X	X					X						X			X		X	X
Mechanical	Package				X				X	X					X	X					X			X		X	X
Mechanical	Fix				X				X	X					X	X					X			X		X	X
Process					X				X	X					X	X										X	X
Electrical					X				X	X					X	X					X			X		X	X
Civil									X	X																	

Work Breakdown Structure (WBS)

TABLE II: THE ARRANGEMENT OF CHANNELS

Engineering Knowledge Area	Knowledge Field	Related Activities	March 2009	May 2009	July 2009	September 2009	November 2009	January 2009	March 2010	May 2010	July 2010	September 2010	November 2010	January 2010	March 2011	May 2011	July 2011	September 2011	November 2011	January 2011
	Mechanical Fix Engineering	Training	■	■	■	■	■	■	■											
		Quality Assurance	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Engineering Supervision	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Purchasing			■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		Manufacturing						■	■	■	■	■	■	■	■	■	■			
		Erection	■	■	■	■	■	■	■	■	■	■	■							
		Fabrication						■	■	■	■	■	■	■	■	■				
		Installation & Hookup							■	■	■	■	■	■	■	■	■			
		Pre-commissioning															■	■	■	■
		Startup																	■	■

TABLE III: COMPARISON RESULTS

Type of measures	ID	Measures
System Measures	1	Number of downloads
	2	Number of submitted LL
	3	Number of users
	4	Contribution rate
Output Measures	5	Usefulness survey
	6	Average quality of LL content improvement
	7	User rating of contribution value
	8	Time to solve problems (Hours)
Outcome Measures	9	Number of revised operating procedures
	10	Average Time saving in operations (Hours)
	11	Average Cost saving in operations
	12	Average reduction in the number of main activity delays
	13	Approximated reduction of learning curve for new employees
	14	Reduction of failures' cost

In the next group of measures (Fig. 8), it is proven that KWBM can influence the rising quality of submitted LL, level of LL management usefulness, average of contribution value and average time to solve problems.

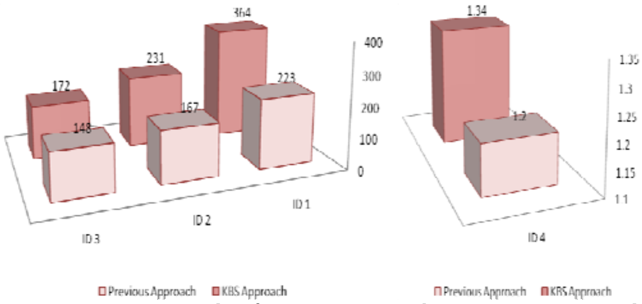

Fig. 7. Comparative results of system measures about previous LLMS and KWBM.

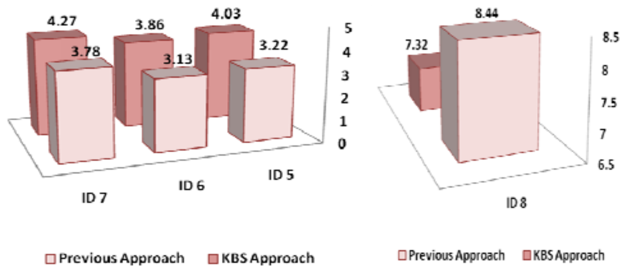

Fig. 8. Comparative results of output measures about previous LLMS and KWBM.

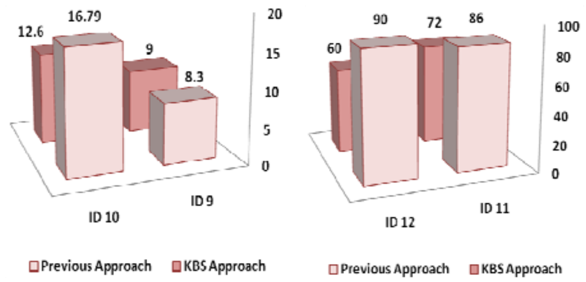

Fig. 9. Comparative results of outcome measures about previous LLMS and KWBM.

The results in outcome measures also confirm (Fig. 9) that using KWBM can be result in improvement of the outcome measures like average cost saving, average failures' cost reduction, number of main activities delays, learning curve reduction, number of revised procedures and average of operational time saving.

D. Results Analysis

Collected data shows that all the measures are improving. The following results wrap up the success analysis of KWBM:

- Using both passive and active approach in LL collection which is considered in KWBM correspondingly results in improving the quantity of submitted LL and the percentage of project member participations, While the previous process merely focused on passive approach and was not as success as KWBM.
- The relationship between KBS and project Gantt chart helps PKO to be assured that critical LLs during deploying a project are submitted. In this case PKO can trace submitting process more actively.
- Knowledge was structured in KBS more systematically than before. It covers all activities of the projects. So, finding and submitting knowledge is much easier.
- The feedback loop that is created during implementation of KWBM leads to improved LL quality and also increasing organizational member participation.
- Based on KWBM, PKO knows which knowledge is needed during each activity. Therefore the possible knowledge leakage will be prevented. By using KWBM, the proper knowledge will be given at the right time to the right person. It leads to a higher level of project member satisfaction.
- Knowledge-based enrichment (in quality and quantity) eventuate to reduce cost and time of the new employees training curve.

VI. Conclusions

Results prove that KWBM is a powerful approach in managing lessons learned in projects. It helps project-oriented organizations to enrich their knowledge base quantitatively and qualitatively. It also helps PKO to share knowledge through the organization to prepare proper existing knowledge, just in time, for deploying in other projects. The results also prove that project members' participation improves during utilizing KWBM as a LLM method. Considering, KWBM make added value for project-oriented organizations seeking for an applicable method in knowledge age.

Acknowledgements

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