Journal of Applied Research and Technology

www.jart.icat.unam.mx

Journal of Applied Research and Technology 21 (2023) 825-849

Original

A methodology for selecting optimal knowledge acquisition through analytic hierarchy process and environment parameters impact

M. Dinardo[a*] • T. Murino[a] • K. Adegbola[b]

[a]*Università degli Studi di Napoli Federico II, Napoli, Italy*
[b]*Wroclaw University of Science and Technology, Wroclaw, Poland*

Received 06 11 2021; accepted 11 04 2022
Available 10 31 2023

Abstract: In a global economy characterised by increasingly dynamic markets and technologies, the primary importance of intangible resources like knowledge is growing dramatically, especially for small and medium-sized enterprises (SME).

Therefore, many companies are trying to support changes by configuring their production systems towards mass customisation. This evolving paradigm shift from mass production to mass customisation brings about complex product lifecycles that require continuous re-engineering/configuration of modern manufacturing systems. Rapid manufacturing companies change results by adjusting and updating their existing knowledge base to maintain their competitive advantage.

Within companies, different tacit and explicit knowledge are available, relating to resources, processes, and components. This data is usually not digitised, and therefore the main challenge for small and medium-sized enterprises is how to automate the knowledge acquisition process and choose the best tools for knowledge preservation. Starting from the analysis of models presented in the literature, we defined a methodology that optimally supports knowledge acquisition and preservation in any phase of production systems. Moreover, in any environment where business uncertainty is the norm, developing knowledge acquisition capabilities is more critical.

This main paper contribution is the AHP-PIE methodology, which provides a helpful guideline as a structured and logical means of ranking knowledge acquisition methods for evaluating appropriate tools for a small manufacturing industry/organisation. The practical example is provided in a sequential order using manually operated assembly and maintenance operations. The result showed that verbal report is the best tool for knowledge acquisition for these engineering practices.

Keywords: Knowledge management, Industry 4.0, analytical hierarchy process (AHP), knowledge-based systems, manufacturing know

*Corresponding author.
E-mail address: mario.dinardo@unina.it (M. Dinardo).
Peer Review under the responsibility of Universidad Nacional Autónoma de México.

1. Introduction

Knowledge management has become a central theme in the scientific studies of business realities. The dynamics of competitive processes, the need for companies to continually scale back their business idea and invest in innovation are some of the main factors contributing immensely to increasing the interest of companies in knowledge management activities. Knowledge is a source of stable and sustainable competitive advantage as it provides the organisation with the potential for new actions and new combinations of pre-existing ideas and concepts. This ensures most organisations develop and include knowledge management strategies and practices in their operational, tactical, and strategic or long-term plans.

This takes place through a complex process both in time and in the organisational space because it requires a long development period and involves all organisational levels and functional areas. The organisation's approach to knowledge management usually occurs gradually: it starts from an initial strategy that involves only a small part of the organisation and then moves on to a more significant structuring of the knowledge management activities until this becomes an integral part of the corporate culture. The success of a knowledge management strategy lies in the organisation's ability to use and consolidate existing knowledge and, at the same time, research, identify, and integrate new knowledge. This remains challenging to small and medium-sized organisations, as they are incomparable to large organizations in terms of technological resources and financial strength. Thus, it becomes imperative for the SMEs to put in place a structure that will enhance and improve the knowledge base and technical know-how of the available human resources within the confinement of their resources.

Given those above, this research work detects a methodology for identifying and digitising an optimal method for knowledge acquisition in small and medium-sized organisations to preserve the employees' tacit knowledge so that employee knowledge is sustained after any process of updating. The paper is organised as follows: Section 2 summarises literature that is related to workers' knowledge management, acquisitions, and information in industries.

Section 3 describes the proposed analytical hierarchy process and environmental parameters impact for knowledge acquisition support *"AHP & PIE for KAS"*.

Section 4 presents the problem formally by describing a manually operated assembly line for SMEs under the European standard. Results obtained from the example are equally presented.

Section 5 presents an integrated software tool developed to support management in the knowledge acquisition phase. Section 6 presents the conclusion.

2. Literature review

Issues related to knowledge management and acquisitions have been of interest to many scholars. However, none has discussed efficient ways to select the most viable knowledge acquisition method for different organisations. Moreover, it becomes imperative for SMEs to acquire knowledge from their employees to preserve their intellectual capital and power over time. Most literature ignored this aspect, leaving a gap between knowledge acquisitions from workers and its role in the company's success. To provide an insight into existing literature, we present some of the related work classified under knowledge acquisition classification methods, workers knowledge management and knowledge acquisition process within SME's as limited to knowledge extracted from information and communication technology (ICT) systems.

2.1. Knowledge acquisition classification method

Cooke (1994) reviewed and organised knowledge elicitation techniques and their related bibliographic information to identify each other's strengths and weaknesses while suggesting possible applications. Hoffman et al. (1995) provided a more in-depth overview of knowledge acquisition techniques, which were further classified under three categories: analysis of task being performed by experts, interview types and contrived techniques. Moody et al. (1999) proposed a taxonomy for knowledge acquisition techniques.

Gavrilova and Andreeva, (2012) argue that most proposed knowledge management/acquisition methods are limited by the idealistic assumptions in knowledge owners' behaviour.

Roth et al. (2014) see knowledge acquisition through a *cognitive task analysis (CTA*) lens and note that KA is nowadays an indispensable tool used to understand the "cognitive and collaborative demands" that contribute to performance and facilitate the formation of expertise. They also note that knowledge acquisition is used as a support for designing ways to improve individual performance through various forms of training, user interfaces, human-machine interaction, or decision-making support systems.

Leu and Abbass (2016) studied the level of involvement of different agencies in the knowledge acquisition process and further proposed classification with three methods: the human agent, the human-inspired agent, and the autonomous machine agent methods.

El-Den and Sriratanaviriyakul (2019) categorise knowledge by identifying ideas and opinions, considered as tacit knowledge, to obtain explicit knowledge. Despite this categorisation into types, no research demonstrates what these types are and how they are related to the tacit.

Baporikar (2020) defines tacit knowledge as implicit knowledge, difficult or even impossible to translate into a speech because it is incommunicable through language; for this reason, sharing is impossible to promote.

These studies concentrated more on the general classification of knowledge acquisition techniques, ignoring a systemic or methodological classification that could aid management decisions on one's choice over the other.

2.2. Workers knowledge management

A company needs to have in its repository employee knowledge to not lose its intellectual capital over time. Henard and McFadyen (2006) affirmed that recognizing knowledge workers' capability as a hierarchy from acquired knowledge to more complex unique and creative knowledge can help improve organizational creativity and innovation in the ever-competitive global business environment. Maruta (2012) redefined the Plan, Do, Check and Act (PCDA) cycle to apply to individual work. Oyefolahan and Dominic (2013) used a quantitative approach to show that the existence of innovative norms in organizations and KMS that provide adequate linkages among knowledge workers are significantly and positively related to the development of autonomous motivation towards KMS use and this, in consequence, contributes significantly to competency development among knowledge workers. Garcia-Sánchez et al. (2017) also studied the influence of different knowledge management processes on organizational performance.

Letmathe and Rößler (2019) promoted the transfer of tacit knowledge through imitation, demonstrating that an expert alongside a new worker improves performance in terms of quality and timing.

Mittal and Kumar (2019) considered the process of creating knowledge to be a continuous and self-transcendent process. The authors stated that organizations could use different knowledge management models according to their needs and organizational structure.

Ibidunn (2020) proposed considering the role of organisational culture on the use of tacit and not tacit knowledge, both individual and group, to deepen organisational knowledge.

However, none of these focuses broadly on knowledge acquisition and the critical role it plays in achieving organizational success.

2.3. Knowledge acquisition process within SME´s as limited knowledge extracted from ICT

Baptista Nunes (2006) reviewed knowledge management tools in SMEs and their impact on the organization's innovation and productivity. Desouza and Awazu (2006) discussed five peculiarities on knowledge management practices in SMEs. The peculiarities identified were the dominance of socialization in the SECI model, shared knowledge, knowledge loss, exploitation of external sources of knowledge, and people-centered knowledge management.

Irani et al. (2009) highlighted that several interlocking factors within an enterprise information system relate to knowledge management and organizational learning, and this type of relationship can lead companies to develop in terms of the learning organization.

Barcelo-Valenzuela et al. (2016) studied SMEs and knowledge acquisition through software systems, neglecting human employees' importance. Johnson (2016) studied the link between knowledge management and SMEs but ignored the importance of building a digital system to manage and develop the acquired knowledge. Muller & Hopf (2017) considered digitalization in SMEs, omitting employee knowledge as a strategic lane to success. Harteis (2018) studied digitalization in SMEs considering knowledge management, but it omits knowledge acquisition and its strategic role.

Vukašinović et al. (2018) argued that the basic principle of the functioning of the KMS is the learning and constant improvement of the enterprise's operation, so a successful implementation of KMS requires that people, processes, and technology should be addressed together, and not individually.

Bratianu (2018) pointed out that, although there is a growing literature analysis on knowledge management, the attention paid to external parameters that impact the process of knowledge acquisition (Environmental parameters impact) is minimal. Therefore, it is essential to focus on those factors that can stimulate or inhibit the knowledge acquisition process.

Hanafizadeh and Ghamkhari (2019) considered elicitation to be a weak problem, proposing a method to explain tacit knowledge, considering tacit knowledge as a system of human activities.

Asher and Popper (2019) promoted the "onion model ", which affirms the existence of three levels of tacit knowledge and demonstrates the links between the different levels: 1° level hidden practical knowledge, the development of such knowledge is based on the acquisition of personal experience; 2° level: actual tacit knowledge, refers to principles that help to make preferences or decisions; 3° level: tacit knowledge demonstrated that includes knowledge that cannot be aroused. This model, however, has not deepened the dynamics that occur between the three layers.

Chergui et al. (2020) proposed an ontological model to capitalise on tacit knowledge, which allows: (1) explicit tacit knowledge; (2) identify and describe the constituent elements of the activity (actor, know-how, situation); (3) reconstruct the activity studied.

Bolade and Sindakis (2020) supported research on the paradigm (psycho-cognitive perspective) as the basis for the theorisation of knowledge creation; this focuses on the triad brain-intelligence rather than IT.

Jha and Sahoo (2021) proposed to increase the efficiency of knowledge management through Big Data and IoT, as these help companies to create a more innovative environment.

3. The analytical hierarchy process and environmental parameters impact for knowledge acquisition support.

This section described the implemented methodology after the research phase.

First, we explain the knowledge acquisition chain that describes the entire process of acquiring knowledge, and it is divided into four distinct phases that must be followed sequentially. The phases are illustrated in Figure 1:

Figure 1.- knowledge acquisition chain.

The process starts by selecting the operators from which we want to acquire knowledgeand ends with the storage of the acquired knowledge.

We focus our attention on the knowledge acquisition phase.

3.1. Analysis framework

The knowledge acquisition phase, being the most crucial, uses a decision support tool that aids management in selecting the best elicitation techniques that are most suitable for a particular case. To have a more transversal solution, it is necessary to identify cluster operations to allow for a more circumscribed and less vague and more generic analysis. The decision support tool is developed in two phases, as shown in Figure 2:

I. The first phase is called static analysis, and it uses AHP (analytical hierarchy process) techniques. Both the knowledge acquisition (KA) methods and the operations of the process being studied will be analyzed individually and jointly.

II. The second phase is a dynamic analysis that considers the external parameters impacting the process, the management, and the workers. It changes the previously obtained hierarchies. This step requires the research of the possible random parameters that may occur in the individual case and the incidence of these parameters on each method considered.

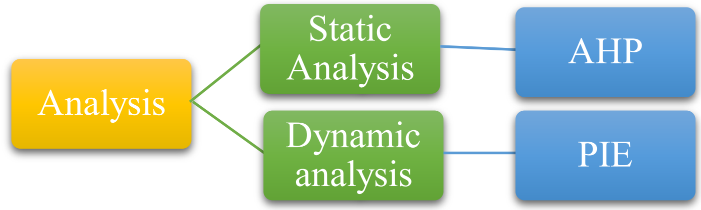

Figure 2. Analysis schema.

3.2. Brief insight on AHP techniques

AHP is one of the most popular MCDM tools for formulating and analyzing decisions, especially in operations management. It is a logical multi-criteria decision-making technique that allows decision-makers to model complex problems based on mathematics and human psychology. It was developed in the seventies by the mathematician Saaty (1984).

The AHP considers a set of evaluation criteria and alternative options, among which the best decision is to be made. It is important to note that, since some of the criteria could be contrasting, it is not valid in general that the best option is the one that optimizes every single criterion, preferably the one which achieves the most suitable trade-off among the different criteria. The AHP generates a weight for each evaluation criterion according to the decision maker's pairwise comparisons of the criteria. The higher the weight, the more critical the corresponding criterion. The AHP assigns a score to each option for a fixed criterion according to the decision maker's pairwise comparisons of the options based on that criterion. The higher the score, the better the performance of the option for the considered criterion. Finally, the AHP combines the criteria weights and the options scores, thus determining each option's global score and a consequent ranking. The global score for a given option is the weighted sum of the scores it obtained with respect to all the criteria.

AHP uses three (3) simple steps:

- Computing the vector of criteria weights.
- Computing the scores of each option against each criterion.
- Ranking the options.

In the end, we explain the steps are assuming m evaluation criteria and n options.

A simple technique for checking the reliability of the results is also discussed.

3.2.1. Computing the vector of criteria weights

To compute the weight for the set criteria, a pairwise comparison matrix A is developed. The matrix A is m×m real matrix, where m is the number of evaluation criteria considered. Each entry a_{jk} of matrix A represents the importance of the jth criterion relative to the kth criterion. If a_{jk}

> 1, then the j^{th} criterion is more important than the kth criterion, while if $a_{jk} < 1$, then the jth criterion is less important than the kth criterion. If two criteria have the same importance, then the entry a_{jk} is 1. The entries a_{jk} and a_{kj} satisfy the following constraint:

$$a_{jk} * a_{kj} = 1. \quad (1)$$

Obviously $a_{jj} = 1$ for all j. The relative importance between the two criteria is measured according to a numerical scale from 1 to 9, as shown in Table 1, where it is assumed that the jth criterion is equally or more important than the kth criterion. The phrases in the "Interpretation" column of Table 1 are only suggestive and may be used to translate the decision maker's qualitative evaluations of the relative importance between two criteria into numbers. It is also possible to assign intermediate values which do not correspond to a precise interpretation. The values in matrix A are, by construction, pairwise consistent. The ratings may show slight inconsistencies. However, these do not pose serious problems in AHP.

Once matrix A is built, it is possible to develop from A the normalised pairwise comparison matrix A_{norm} by making the sum of the entries on each column equal to 1, i.e., each entry ajk of the matrix A_{norm} is computed as

$$\overline{a}_{jk} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{lk}} \quad (2)$$

Lastly, the criteria weight vector w (m-dimensional column vector) is built by averaging the entries on each row of A_{norm}, i.e.

$$w_j = \frac{\sum_{l=1}^{m} \bar{a}_{jl}}{m} \quad (3)$$

Table 1. Table of relative scores.

Value of a_{jk}	Interpretation
1	j and k are equally important
3	j is slightly more important than k
5	j is more critical than k
7	j is strongly more important than k
9	j is more important than k

3.2.2. Computing the scores of each option against each criterion

The option scores matrix is *n*×*m* real matrix **S**. Each entry s_{ij} of **S** represents the score of the *i*th option concerning the *j*th criterion. To derive such scores, a *pairwise comparison matrix* $B^{(j)}$ is first built for each of the *m* criteria, *j=1……m*. The matrix $B^{(j)}$ is n×*n* real matrix, where *n* is the number of options evaluated.

Each entry $b_{ih}^{(j)}$ of the matrix $B^{(j)}$ represents the *i*th option's evaluation compared to the *h*th option concerning the *j*th criterion. If $b_{ih}^{(j)}>1$, then the *i*th option is better than the *h*th option, while if $b_{ih}^{(j)}<1$, then the *i*th option is worse than the *h*th option. If two options are evaluated as equivalent to the *j*th criterion, the entry $b_{ih}^{(j)}$ is 1. The entries $b_{ih}^{(j)}$ and $b_{hi}^{(j)}$ satisfy the following constraint:

$$b_{ih}^{(j)} * b_{hi}^{(j)} = 1 \quad (4)$$

and $b_{ii}^{(j)}$ for all *i*. An evaluation scale like the one introduced in Table 1 may be used to translate the decision maker's pairwise evaluations into numbers.

Furthermore, the AHP applies to each matrix $B^{(j)}$ the two-steps described for the pairwise comparison matrix **A**, i.e., it divides each entry by the sum of the entries in the same column, and then it averages the entries on each row, thus obtaining the score vectors $s^{(j)}$, *j=1…. m.* The vector $s^{(j)}$ contains the scores of the evaluated options concerning the *j*th criterion.

Finally, the score matrix **S** is obtained as:

$$S = [\, s(1) \ldots s(m) \,] \quad (5)$$

i.e., the *j*th column of **S** corresponds to $s^{(j)}$

It is worthy of note that the pairwise option evaluations are performed by comparing the performance indicators' values corresponding to the decision criteria. Hence, this step of the AHP can be considered a transformation of the indicator matrix **I** into the score matrix **S**.

3.2.3. Ranking the options

Once the weight vector ***w*** and the score matrix **S** have been computed, the AHP obtains a vector **v** of global scores by multiplying **S** and **w**, i.e.

$$v = S \cdot w \quad (6)$$

The *i*th entry v_i of **v** represents the global score assigned by the AHP to the *i*th option. As the last step, the option ranking is accomplished by ordering the global scores in decreasing order.

3.2.4. Checking the consistency

When many pairwise comparisons are performed, some inconsistencies may typically arise. The AHP incorporates an effective technique for checking the consistency of the decision maker. The technique relies on the computation of a suitable *consistency index*, which is described only for matrix A as an example. The technique is easy to adapt for matrix $B^{(j)}$ by replacing A with $B^{(j)}$, *w* with $s^{(j)}$, and *m* with *n*.

The *consistency index* (*CI*) is obtained by first computing the scalar *x* as the average of the vector's elements whose *j*th element is the ratio of the *j*th element of the vector A·*w* to the corresponding element of the vector *w*. Then,

$$CI = \frac{x-m}{m-1} \quad (7)$$

A very consistent decision-maker should always have $CI = 0$, but small values of inconsistency may be tolerated if

$$\frac{CI}{RI} < 0.1 \quad (8)$$

RI is the Random Index, i.e., the consistency index when the entries of A are completely random. The values of *RI* for small problems ($m \leq 10$) are shown in Table 2:

For this study, RI values according to Alonso and Lamata (2006), were used. This is shown in Table 3 below:

Table 2. Values of the random index (RI) for small problems.

m	RI
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.51

Table 3. Values of the random index (RI) obtained from Alonso and Lamata (2006).

m	RI
3	0.5245
4	0.8815
5	1.1086
6	1.2479
7	1.3417
8	1.4056
9	1.4499
10	1.4854

3.3. Brief insight on PIE

PIE stands for environmental parameters impact. The parameters considered are those that influence the operations conducted within the considered manually operated assembly line.

The parameters include the moment in which the knowledge must be acquired, item dimension, static level of workplace, noise level, verbal capability of the employee, possibility to use e-device near the machine and privacy constraints.

At the end, a hybrid methodology called "AHP & PIE for KAS (analytic hierarchy process and environmental parameters impact for knowledge acquisition support)" is obtained. This hybrid methodology exploits the potential of the AHP to reach a hierarchy of knowledge acquisitions methods by considering at the same time the operations that the operators perform and the parameters that influence them.

4. Application of the proposed *"AHP & PIE for Kas"* method to a manually operated assembly line for Sme's.

This section, which consists of eleven steps, is aimed at getting the results that the digital tool will use. At the end, we would obtain a classification for each operation that was performed by the operator (assembly/maintenance). To achieve these rankings, we used the AHP methodology, which uses pairwise comparisons, and allows us to obtain quantitative data from qualitative considerations. All data are collected from an Industrial firm, and the parameters obtained in relation to the considered assembly line are emphasized during the study.

4.1. Step 1

Step 1 identifies all knowledge elicitation tools that are to be involved in the methodology. The captured tools are shown in Table 4. Each of these tools is unique and differs from others based on set parameters that will be discussed later.

Table 4. Elicitation tools.

ELICITATION TOOLS
Observation
Unstructured Interview
Structured Interview
Cognitive Task Analysis
Part
Verbal Reports
Non-Verbal Reports
Protocol Analysis
Error Analysis
Sensory-Motor Process Chart

4.2. Step 2

Step 2 identifies specific knowledge clusters for maintenance and assembly operations, as shown in Table 5. Only one manual task is considered for the assembly task, while for maintenance, operations involving both predictive and corrective maintenance are considered.

4.3. Step 3

Step 3 shown in Table 6, identifies all generic parameters related to knowledge elicitation tools chosen in Step 1. Each tool presents distinct levels of these parameters on a qualitative scale i.e., “very low”, “low”, “medium”, “high”, and “very high”. The identification of these levels is discussed in Step 5.

4.4. Step 4

Step 4 presented in Table 7 identifies all generic parameters that are related to both maintenance and assembly operations.

Table 5. Assembly and maintenance operations

Assembly Operations	Maintenance Operations
Manipulation of objects	*Inspection*
Coupling between two components	*Condition monitoring*
Screwing	*Compliance testing*
Pressing	*Function check out*
Bonding	*Routine Maintenance*
Deposition of sealants	*Overhaul*
Intermediate Check	*Fault diagnosis*
	Fault localisation
	Repair
	Maintenance task preparation
	Maintenance schedule

These parameters are chosen after a thorough analysis of the maintenance and assembly process. The choice is consistent and dictated by the need to find an individual correspondence between these and those parameters. Each operation presents distinct levels of these parameters on a qualitative scale i.e., “very low”, “low”, “medium”, “high”, and “very high”. The identification of these levels is further discussed in Step 5.

4.5. Step 5

Step 5 creates a classification of knowledge elicitation tools using AHP techniques so that each tool can have a "level" for each parameter. Seven (7) AHP analyses were performed to achieve this, and for each parameter, the tool is marked by a ranking. The hierarchical structure is presented in Figure 3. Obviously, this ranking is normalised on a scale of one (1) to five (5); this represents the numerical quality rating very low", "low," "medium", "high", and "very high" that will be assigned to each parameter for each tool.

Table 6. Parameters related to the knowledge elicitation tools.

General parameters selected for knowledge elicitation tools
Time and resources requirements
Data content richness
Capability to obtain verbally expressed knowledge
Capability to obtain knowledge expressed by gestures and actions
Capability to explain the sequence of tasks
Capability to analyse a decision critically
Capability to analyse the specific scenario

Table 7. Parameters related to maintenance and assembly operations.

Parameters selected for Maintenance and Assembly operations
Complexity
Capability to be expressed verbally
Capability to be expressed by gestures and actions
Time and other resources incurred on the operations
How standardised is the operation
How much is the operation case-based
Level of knowledge as a function of experience
Critical assessments required for the operation

In addition, five (5) cluster making approximations were created to fit every normalised rank, and for the random index (RI), which by nature is experimental, we adopt the work of Alonso and Lamata (2006). This results in an-array for each tool, and each cell has a value from 1 to 5, which is the qualitative assessment for the parameter. For example, consider the parameter "Time and resources required," a full pairwise comparison of the knowledge elicitation methods to show the difference is provided in Table 8, after which the numbers in the grids are normalised and reported in Table 9.

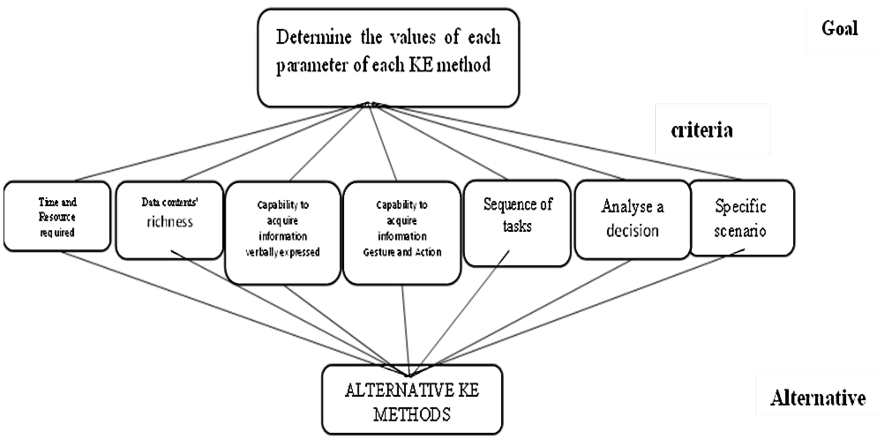

Figure 3. Hierarchical structure for classifying knowledge elicitation tools.

Table 8. Pairwise comparisons matrix – "time and resources required."

	OBSERVATION	U. INTERVIEW	S. INTERVIEW	COGNITIVE TASK / WALKTROUGHS ANALYSIS	PARI	VERBAL REPORTS	NON VERBAL REPORTS	PROTOCOL ANALYSIS	ERROR ANALYSIS	SENSORI-MOTOR PROCESS CHART
OBSERVATION	1,00	0,20	0,14	0,50	0,20	2,00	3,00	0,25	0,33	4,00
U. INTERVIEW	5,00	1,00	0,33	3,00	0,50	6,00	7,00	2,00	3,00	8,00
S. INTERVIEW	7,00	3,00	1,00	6,00	2,00	8,00	9,00	4,00	5,00	9,00
COGNITIVE TASK / WALKTROUGHS ANALYSIS	2,00	0,33	0,17	1,00	0,20	3,00	4,00	0,33	0,25	5,00
PARI	5,00	2,00	0,50	5,00	1,00	7,00	8,00	3,00	4,00	8,00
VERBAL REPORTS	0,50	0,17	0,13	0,33	0,14	1,00	2,00	0,20	0,25	3,00
NON VERBAL REPORTS	0,33	0,14	0,11	0,25	0,13	0,50	1,00	0,17	0,20	2,00
PROTOCOL ANALYSIS	4,00	0,50	0,25	3,00	0,33	5,00	6,00	1,00	2,00	7,00
ERROR ANALYSIS	3,00	0,33	0,20	4,00	0,25	4,00	5,00	0,50	1,00	7,00
SENSORI-MOTOR PROCESS CHART	0,25	0,13	0,11	0,20	0,13	0,33	0,50	0,14	0,14	1,00

Table 9. Normalised matrix of pairwise comparisons – “time and resources required”.

	OBSERVATION	U. INTERVIEW	S. INTERVIEW	COGNITIVE TASK / WALKTROUGHS ANALYSIS	PARI	VERBAL REPORTS	NON VERBAL REPORTS	PROTOCOL ANALYSIS	ERROR ANALYSIS	SENSORI-MOTOR PROCESS CHART
OBSERVATION	0,04	0,03	0,05	0,02	0,04	0,05	0,07	0,02	0,02	0,07
U. INTERVIEW	0,18	0,13	0,11	0,13	0,10	0,16	0,15	0,17	0,19	0,15
S. INTERVIEW	0,25	0,38	0,34	0,26	0,41	0,22	0,20	0,35	0,31	0,17
COGNITIVE TASK / WALKTROUGHS ANALYSIS	0,07	0,04	0,06	0,04	0,04	0,08	0,09	0,03	0,02	0,09
PARI	0,18	0,26	0,17	0,21	0,21	0,19	0,18	0,26	0,25	0,15
VERBAL REPORTS	0,02	0,02	0,04	0,01	0,03	0,03	0,04	0,02	0,02	0,06
NON VERBAL REPORTS	0,01	0,02	0,04	0,01	0,03	0,01	0,02	0,01	0,01	0,04
PROTOCOL ANALYSIS	0,14	0,06	0,09	0,13	0,07	0,14	0,13	0,09	0,12	0,13
ERROR ANALYSIS	0,11	0,04	0,07	0,17	0,05	0,11	0,11	0,04	0,06	0,13
SENSORI-MOTOR PROCESS CHART	0,01	0,02	0,04	0,01	0,03	0,01	0,01	0,01	0,01	0,02

Table 10 presented the ranking from the normalised AHP and put them into clusters from 1 to 5 which implies very low to very high. Table 11 presented the consistency analysis.

Table 10. Ranking values and normalised ranking values.

wi	Normalised value
0,14	5
0,51	3
1,00	1
0,19	5
0,71	2
0,10	5
0,07	5
0,38	4
0,31	4
0,05	5

Table 11. Consistency analysis.

CI	0,07
RI	1,49
CR	0,05

4.6. Step 6

Step 6 creates AHP logic classification for maintenance and assembly operations, such that each of them is assigned a "level" for each parameter. To achieve this, 8 AHP’s analysis were performed, and the hierarchical structure is provided in Figure 4.

To locate a level for each parameter, pairwise comparisons between operations must be obtained for the given parameter, and the tool is marked by ranking. This ranking is normalised on a scale of one (1) to five (5), and like Step 5, five (5) cluster making approximations were created to fit every normalised rank. For the random index (RI), which by nature is experimental, we adopt the work of Alonso and Lamata (2006).

This results in an array for each operation and each cell has a value from 1 to 5 which is the qualitative assessment for the parameter. To give an example, consider the parameter "Complexity," a full pairwise comparison of the knowledge elicitation methods to show the difference is provided in Table 12, after which the numbers in the grids are normalised and reported in Table 13.

Table 14 presented the ranking from the normalised AHP and put it into clusters from 1 to 5 which implies very low to very high. Table 15 presented the consistency analysis.

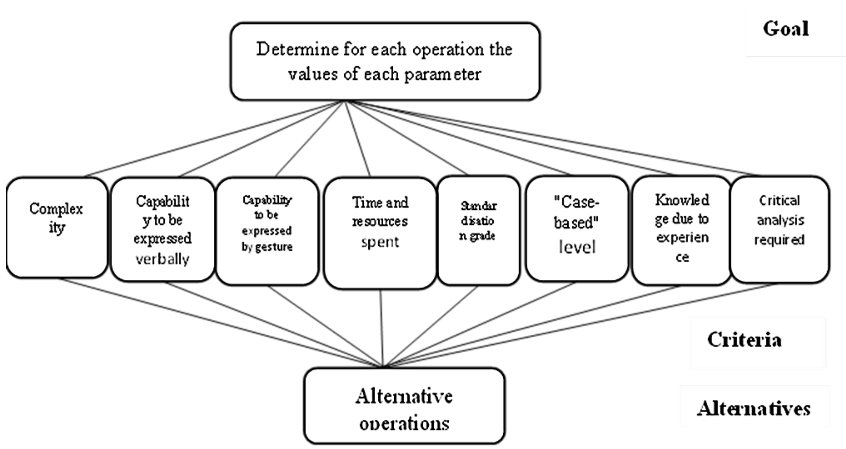

Figure 4. Hierarchical structure for classifying knowledge elicitation tools.

Table 12. Matrix of pairwise comparisons – "complexity."

	manipulation of objects	coupling between two components	screwing	pressing	bonding	deposition of sealants	intermediate checks
manipulation of objects	1,00	0,142857143	0,166667	0,25	0,5	0,333333333	0,25
coupling between two components	7,00	1,00	2	4	6	5	3
screwing	6,00	0,50	1,00	3	5	4	2
pressing	4,00	0,25	0,33	1,00	3	2	0,5
bonding	2,00	0,17	0,20	0,33	1,00	0,5	0,25
deposition of sealants	3,00	0,20	0,25	0,50	2,00	1,00	0,333333333
intermediate checks	4,00	0,33	0,50	2,00	4,00	3,00	1

Table 13. Normalised matrix of pairwise comparisons – “complexity.”

	manipulation of objects	coupling between two components	screwing	pressing	bonding	deposition of sealants	intermediate checks
manipulation of objects	0,04	0,06	0,04	0,02	0,02	0,02	0,03
coupling between two components	0,26	0,39	0,45	0,36	0,28	0,32	0,41
screwing	0,22	0,19	0,22	0,27	0,23	0,25	0,27
pressing	0,15	0,10	0,07	0,09	0,14	0,13	0,07
bonding	0,07	0,06	0,04	0,03	0,05	0,03	0,03
deposition of sealants	0,11	0,08	0,06	0,05	0,09	0,06	0,05
intermediate checks	0,15	0,13	0,11	0,18	0,19	0,19	0,14

4.7. Step 7

Step 7 assigns a ranking for each operation parameter in relation to the knowledge elicitation tools parameters to provide in logic AHP "coefficient of importance" for the knowledge elicitation tool parameter in relation to a specific parameter of the specific operation. This is important for the next step to calculate the fitness index. The hierarchical structure for this stage is presented in Figure 5.

Table 14. Ranking values and normalised ranking values.

wi	Normalised value
0,09	5
1,00	1
0,68	2
0,30	4
0,13	5
0,20	5
0,44	3

Table 15. Consistency analysis.

CI	0,03
RI	1,34
CR	0,03

Here, the design is made to prioritise the knowledge elicitation tools parameters over those of operations to know which weigh more or less. Meanwhile, if compared with the two previous stages, normalisation is not done on a scale of one (1) to five (5) clusters. It is obtained directly from the AHP as shown in Step 10, and for the choice of random index, the work of Alonso and Lamata (2006) is embraced.

To provide an example, consider the parameter “complexity.” Table 16 shows a pairwise comparison among the knowledge elicitation methods to show all differences. The numbers are then normalised in grids and reported in Table 17. Table 18 shows the ranked values from AHP, and the same values are normalised and put into clusters from 1 to 5 which implies very low-very high.

4.8. Step 8

Step 8 generates a reference table that presents the minimum value for the given parameter level in each cell. This is necessary because, with this, all cases are considered; the solution begins to take the form of a database from which we want to extract structured query under tables depending on the choice of the input transaction, which means it will act as a trigger to activate the query. The minimum values for each parameter of the knowledge elicitation tool for each level of parameters of maintenance and assembly operations is shown in Table 20.

4.9. Step 9

Step 9 assign values to parameters for each operation. This is possible by extracting the rows for specific operations in Step 8 each time there is a perfect blend of parameters for knowledge elicitation tools. It is important to note that based on the property set from the previous step, there is space for introducing new operations with different parameter levels. Table 21 shows the values assigned to each parameter for each operation.

4.10. Step 10

Step 10 evaluates how much the method adapts to the analysed operation using the simple additive weighting techniques (SAW). An evaluation score is calculated based on Salehi and Izadikhah (2014) methodology, and a fitness index is computed for each tool.

If the value is greater than or equal to the required (ideal), then the decision variable value is 1, otherwise 0.

The model is presented below:

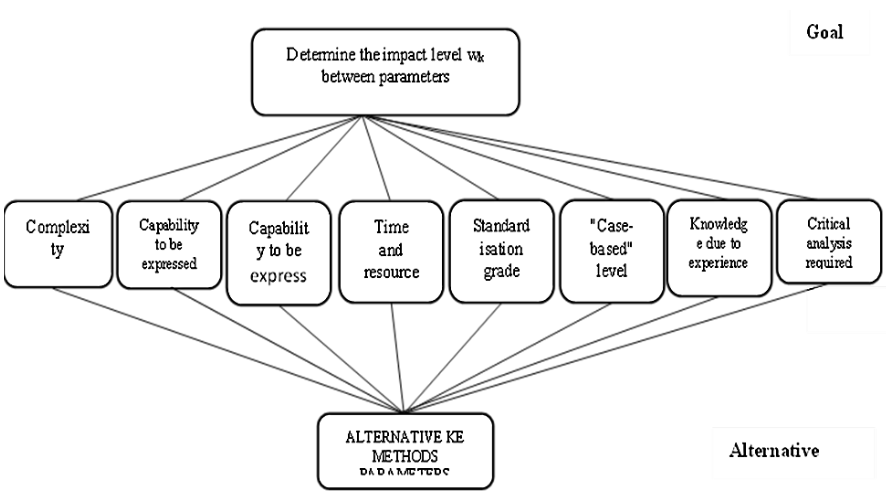

Figure 5. Hierarchical structure for ranking operation parameter against knowledge elicitation tools parameter.

Table 16. Matrix of pairwise comparisons – "complexity".

	Time and resources	Data content richness	…verbally expressed	…gestures and actions	Specific scenario	Sequence of task	Analyse a decision
Time and resources required	1,00	0,50	4,00	5,00	6,00	3,00	2,00
Data content richness	2,00	1,00	5,00	6,00	7,00	4,00	3,00
…verbally expressed	0,25	0,20	1,00	2,00	3,00	0,50	0,33
…gestures and actions	0,20	0,17	0,50	1,00	2,00	0,33	0,25
Specific scenario	0,17	0,14	0,33	0,50	1,00	0,25	0,20
Sequence of task	0,33	0,25	2,00	3,00	4,00	1,00	0,50
Analyse a decision	0,50	0,33	3,00	4,00	5,00	2,00	1,00

Table 17. Normalised matrix of pairwise comparisons – "complexity."

	Time and resources	Data content richness	…verbally expressed	…gestures and actions	Specific scenario	Sequence of task	Analyse a decision
Time and resources required	0,22	0,19	0,25	0,23	0,21	0,27	0,27
Data content richness	0,45	0,39	0,32	0,28	0,25	0,36	0,41
…verbally expressed	0,06	0,08	0,06	0,09	0,11	0,05	0,05
gestures and actions	0,04	0,06	0,03	0,05	0,07	0,03	0,03
Specific scenario	0,04	0,06	0,02	0,02	0,04	0,02	0,03
Sequence of task	0,07	0,10	0,13	0,14	0,14	0,09	0,07
Analyse a decision	0,11	0,13	0,19	0,19	0,18	0,18	0,14

Notations

n = number of knowledge elicitation methods parameters

m = number of knowledge elicitation method

w_k = the "impact level" of each knowledge elicitation methods parameter over each operation parameter. It is the coefficient obtained in the 7th phase

$v_k = 0 \; or \; 1$

Table 18. Ranking values and normalised ranking values.

wi	Normalised value
0,68	4
1,00	5
0,20	1
0,13	1
0,09	1
0,30	2
0,45	3

Table 19. Consistency analysis.

CI	0,03
RI	1,34
CR	0,02

v_k=0 if the level of KE method parameters is less than the mínimum level needed (phase 8), otherwise 1.

FI = Fitness index

$$FI_i = \sum_{k=1}^{n} w_k * v_k \quad \forall\, i = 1,2 \ldots \ldots \ldots \ldots m \qquad (9)$$

In this case, the value v_k is a binary variable that indicates the adaptation of the knowledge elicitation method's single parameter to the minimum level required for that parameter of the operation. Table 22 gives the final fitness index for each knowledge elicitation method for the operation "manipulation of objects".

Table 20. Table of minimum values for each parameter of knowledge elicitation tool for each level of each parameter maintenance and assembly operations.

	Knowledge elicitation methods parameters						
	Time and resources	Data content's richness	Obtain "verbally" knowledge	Obtain "gestures" knowledge	Sequence of tasks	Analyse a decision critically	Specific scenario
Complexity							
VL	1	1	1	1	1	1	1
L	2	2	2	2	2	2	2
M	3	3	3	3	3	3	3
H	4	4	4	4	4	4	4
VH	5	5	5	5	5	5	5
…expressed verbally							
VL	5	5	1	5	5	1	5
L	4	4	2	4	4	2	4
M	3	3	3	3	3	3	3
H	2	2	4	2	2	4	2
VH	1	1	5	1	1	5	1
…expressed by gesture							
VL	5	5	5	1	5	5	5
L	4	4	4	2	4	4	4
M	3	3	3	3	3	3	3
H	2	2	2	4	2	2	2
VH	1	1	1	5	1	1	1
Time and resources							
VL	1	1	5	5	5	1	1
L	2	2	4	4	4	2	2
M	3	3	3	3	3	3	3
H	4	4	2	2	2	4	4
VH	5	5	1	1	1	5	5

Standardisation grade							
VL	5	5	5	5	5	5	5
L	4	4	4	4	4	4	4
M	3	3	3	3	3	3	3
H	2	2	2	2	2	2	2
VH	1	1	1	1	1	1	1
"Case-based level"							
VL	1	1	1	1	1	1	1
L	2	2	2	2	2	2	2
M	3	3	3	3	3	3	3
H	4	4	4	4	4	4	4
VH	5	5	5	5	5	5	5
Experience level							
VL	1	1	1	1	1	1	5
L	2	2	2	2	2	2	4
M	3	3	3	3	3	3	3
H	4	4	4	4	4	4	2
VH	5	5	5	5	5	5	1
Critical analysis needed							
VL	1	1	1	1	1	1	1
L	2	2	2	2	2	2	2
M	3	3	3	3	3	3	3
H	4	4	4	4	4	4	4
VH	5	5	5	5	5	5	5

Table 21. Values of parameters for each operation.

		Time and resources	Data content's richness	Obtain "verbally" knowledge	Obtain "gestures" knowledge	Sequence of tasks	Analyse a decision critically	Specific scenario
manipulation of objects	Complexity	5	5	5	5	5	5	5
	…expressed verbally	1	1	5	1	1	5	1
	…expressed by gesture	1	1	1	5	1	1	1
	Time and resources	5	5	1	1	1	5	5
	Standardisation grade	5	5	5	5	5	5	5
	"Case-based level"	5	5	5	5	5	5	5
	Experience level	1	1	1	1	1	1	5
	Critical analysis needed	1	1	1	1	1	1	1
coupling between two components	Complexity	1	1	1	1	1	1	1
	…expressed verbally	5	5	1	5	5	1	5
	…expressed by gesture	5	5	5	1	5	5	5
	Time and resources	1	1	5	5	5	1	1
	Standardisation grade	3	3	3	3	3	3	3
	"Case-based level"	3	3	3	3	3	3	3
	Experience level	4	4	4	4	4	4	2
	Critical analysis needed	4	4	4	4	4	4	4
screwing	Complexity	2	2	2	2	2	2	2
	…expressed verbally	2	2	4	2	2	4	2
	…expressed by gesture	4	4	4	2	4	4	4
	Time and resources	4	4	2	2	2	4	4
	Standardisation grade	5	5	5	5	5	5	5
	"Case-based level"	4	4	4	4	4	4	4
	Experience level	2	2	2	2	2	2	4
	Critical analysis needed	2	2	2	2	2	2	2

pressing	Complexity	4	4	4	4	4	4	4
	…expressed verbally	3	3	3	3	3	3	3
	…expressed by gesture	2	2	2	4	2	2	2
	Time and resources	4	4	2	2	2	4	4
	Standardisation grade	4	4	4	4	4	4	4
	"Case-based level"	1	1	1	1	1	1	1
	Experience level	1	1	1	1	1	1	5
	Critical analysis needed	1	1	1	1	1	1	1
bonding	Complexity	5	5	5	5	5	5	5
	…expressed verbally	4	4	2	4	4	2	4
	…expressed by gesture	1	1	1	5	1	1	1
	Time and resources	5	5	1	1	1	5	5
	Standardisation grade	5	5	5	5	5	5	5
	"Case-based level"	2	2	2	2	2	2	2
	Experience level	1	1	1	1	1	1	5
	Critical analysis needed	1	1	1	1	1	1	1
deposition of sealants	Complexity	5	5	5	5	5	5	5
	…expressed verbally	5	5	1	5	5	1	5
	…expressed by gesture	1	1	1	5	1	1	1
	Time and resources	1	1	5	5	5	1	1
	Standardisation grade	2	2	2	2	2	2	2
	"Case-based level"	1	1	1	1	1	1	1
	Experience level	3	3	3	3	3	3	3
	Critical analysis needed	3	3	3	3	3	3	3
intermediate checks	Complexity	3	3	3	3	3	3	3

intermediate checks	Complexity	3	3	3	3	3	3	3
	…expressed verbally	5	5	1	5	5	1	5
	…expressed by gesture	3	3	3	3	3	3	3
	Time and resources	1	1	5	5	5	1	1
	Standardisation grade	1	1	1	1	1	1	1
	"Case-based level"	1	1	1	1	1	1	1
	Experience level	5	5	5	5	5	5	1
	Critical analysis needed	5	5	5	5	5	5	5

Table 22. Method ranking for ‘‘manipulation of objects.’’

VERBAL REPORTS	5,77
NON VERBAL REPORTS	4,62
COGNITIVE TASK / WALKTHROUGHS ANALYSIS	4,46
OBSERVATION	4,13
SENSORI-MOTOR PROCESS CHART	4,13
U. INTERVIEW	3,92
ERROR ANALYSIS	3,77
S. INTERVIEW	3,14
PARI	3,14
PROTOCOL ANALYSIS	3,14

4.11. Step 11

Step 11 considers environmental parameters as a constraint in our analysis, as these might influence the ranking obtained from the fitness index table. Environmental parameters are dynamic i.e., they change constantly with time and might impact the best tool's choice.

There are almost infinite environmental parameters to consider, but in this work, only the most important ones are considered according to the assembly line considered as explained in Table 23:

Table 23. Selected environmental parameters.

ENVIRONMENTAL PARAMETER	DESCRIPTION
Knowledge acquisition moment	*Knowledge acquisition can be made during or after the operation. Acquiring knowledge during operation is usually the best. However, it is sometimes difficult and expensive as special technologies might be required.*
Item dimension	*Item size and dimensions might necessitate specific KE tool*
Nature of Workstations	*Some workstations required employee movement from time to time and this might capture or record very difficult.*
Noise level	*A decibel scale with stringent penalty metrics is created for a verbal operation report.*
Employee verbal capability	*This is the most important parameter even though it is difficult to consider from an engineering perspective. This is measured by the percentage of employee verbal speech that the managers understand. A penalty metric is introduced.*
Possibility to use electronic devices near the machine	*This determines the choice of technology as some technological systems find this incompatible.*
Privacy	*Infringing on employee's privacy may not be possible on rare occasions.*

5. The developed *"AHP & PIE for KAS"* decision support tool

The primary objective of this research is to develop a tool that will support management decisions in the choice of employee's knowledge acquisition method. A decision support system (DSS) refers to a decision support software system that supports management in making strategic decisions, mainly
when operation research solutions are not viable. Such a tool must be cheap, user-friendly, effective, efficient, and transversal for any process e.g., assembly, maintenance etc.To develop this tool, a user form is first developed in Excel. More specifically, in different user forms linked together through "button". For the realization of the user form, VBA language is used. This user form queries the management on a range of issues that may impact the process. The tool provides a questionnaire that allows for accurate and careful analysis. The first user form is shown in Figure 6.

Figure 6. First user form.

This interface introduces and provides a detailed directory of the tool. By clicking the "Go" button, you switch to the second user form (Figure 7) that enables users to choose which process to analyze, e.g., assembly, maintenance etc.

The next user form transfer users to the desired process page as shown in Figure 8 and 9:

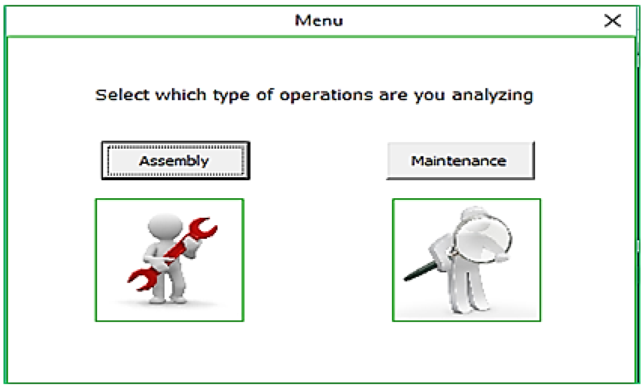

Figure 7. Second user form.

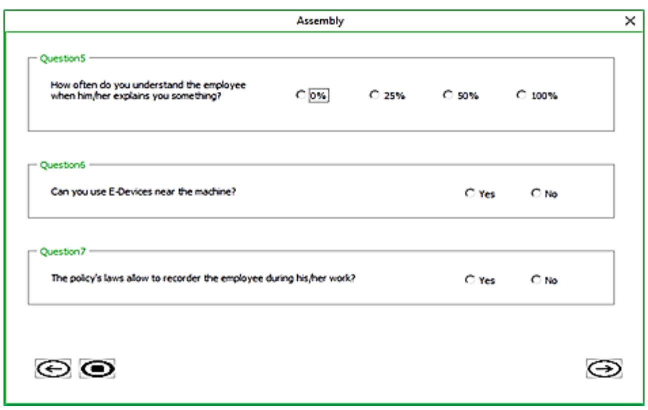

Figure 8. Third user form.

On these user forms, the user answered several questions concerning parameters that are impacting the operations. By selecting the task, you get the list of the knowledge acquisition methods that are related to the selected operation. The ranking/arrangement is done according to the analysis made in Section 4. This ranking will change based on a specific evaluation metric (Table 24) that is being induced by answering questions requested in the questionnaire. Each response penalizes one or more ranking methods through a coefficient generated from the metric.

Notably, the tool impacts the methods and the technologies in support of each method well as shown in Figure 9. The first five questions impacted the methods according to the set metric, and the last two questions impacted the technologies. For the technologies, the questions are not restrictive. Thus, they never impact the choice of technology quantitatively, but are helpful in providing results.

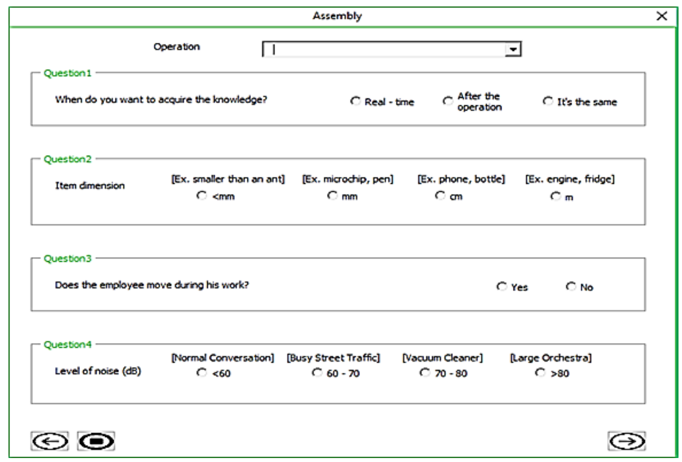

Figure 9. Fourth user form.

The last user form that gives the result is shown in Figure 10. By clicking the "Go" icon, the user form performs the analysis and ranking is done concerning the input parameters. The percentage fitness rate of the method for a specific operation is thus computed as

$$FR = 100\left[\frac{method\ fitness\ index}{max(methods\ fitness\ index)}\right] \tag{10}$$

At the end of this questioning phase, we have a list of parameters that take into consideration the structural parameters of methods, operations (analyzed using the AHP) and processes.

Moreover, for each method, the tool additionally shows the technology associated with it that can be used to digitize the data and store it in the company's databases.

Table 25 shows the association "method – technology," and then explains each technology.

Table 24. Evaluation metric.

		Question1			Question2				Question3		Question4				Question5			
		Real time	After	It's the same	<mm	mm	cm	m	Yes	No	<60	60-70	70-80	>80	0%	25%	50%	100%
METHODS	OBSERVATION	1	0	1	0	0,3	0,6	1	0	1	1	1	1	1	1	1	1	1
	U. INTERVIEW	0	1	1	1	1	1	1	1	1	1	1	1	1	0,2	0,5	0,8	1
	S. INTERVIEW	0	1	1	1	1	1	1	1	1	1	1	1	1	0,3	0,6	0,9	1
	COGNITIVE TASK / WALKTROUGHS ANALYSIS	0	1	1	1	1	1	1	1	1	1	1	1	1	0,3	0,6	0,9	1
	PARI	0	1	1	1	1	1	1	1	1	1	1	1	1	0,3	0,6	0,9	1
	VERBAL REPORTS - online	1	0	1	0	0,3	0,6	1	1	1	1	0,6	0,3	0	0,1	0,4	0,7	1
	VERBAL REPORTS - no-online	0	1	1	1	1	1	1	1	1	1	0,6	0,3	0	0,1	0,4	0,7	1
	NON VERBAL REPORTS	1	0	1	0	0,3	0,6	1	0	1	1	1	1	1	1	1	1	1
	PROTOCOL ANALYSIS	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	ERROR ANALYSIS	0	1	1	1	1	1	1	1	1	1	1	1	1	0,3	0,6	0,9	1
	SENSORI-MOTOR PROCESS CHART	0	1	1	1	1	1	1	1	1	1	1	1	1	0,3	0,6	0,9	1

		Question6		Question7	
		Yes	No	Yes	No
Technologiess	PCPACK Software	Yes	Yes	Yes	Yes
	Kinekt	Yes	Yes	Yes	Yes
	Audio Recordering	Yes	NO	Yes	Yes
	Camera Recording	Yes	NO	Yes	NO
	EMG-Based Biofeedback	Yes	Yes	Yes	Yes
	KRITON	Yes	Yes	Yes	Yes

Figure 10. Last user form of the tool.

Table 25. Technologies associated with each knowledge elicitation method.

KE Methods	Technologies Associated
Observation	Camera Recording
Structured Interview	Cognosis\Kriton
Unstructured Interview	Cognosis\Kriton
PARI	PCPACK
Cognitive Walkthroughs	PCPACK
Verbal Report	Audio Recordering
Non-Verbal Report	Kinekt
Protocol Analysis	Cognosis \ PCPACK
Error Analysis	Cognosis\PCPACK
Sensori Motor Chart	Kinekt

- Kriton

All information in this section is extracted from Diederich et al. (1987).

The work presented a hybrid system for knowledge acquisition. It combines both artificial intelligence and cognitive methods to create a knowledge base.

The method is named Kriton and today it is a widely used commercial software.

The goal structure of the knowledge elicitation methods is an intermediate knowledge-representation language on which frame, rule and constraints generators operate to build up the final knowledge base.

From Figure 11 above, we can see the structure behind this software; three knowledge elicitation methods are used: an automated interview, text analysis and protocol analysis. After a complete process and a consistency check, the information is transformed into an intermediate knowledge representation language consisting of a descriptive language for functional and physical objects and propositional calculus. Frame, rule, and constraint generators operating on the intermediate representation level are finally used to build up the destination knowledge base. On the other hand, the already acquired knowledge guides the employment of the elicitation methods to complete the knowledge base incrementally.

This methodology is also hybrid because it uses information from various sources so that the knowledge base can be very rich and variegated; this is the strong point of Kriton.

- PcPack

PCPACK is a network-enabled application that allows knowledge bases to be stored and accessed by multiple users over a network. Each user has defined access rights that allow or restrict their ability to edit and view certain knowledge bases.

The management of knowledge bases is controlled by a central administrator - called a tool administrator - who manages version control of knowledge bases.

PCPACK has been developed as part of the ongoing development of the PCPACK family to satisfy the requirements of large organizations that require multiple users of a single knowledge base.

- Camera recording

Recording employees during their work is not something innovative.

For a long time, people have been recorded in their workplace but only for safety reasons.

The innovation here is how the technology is deployed: employees are recorded to track their work, gestures, and behavior. This requires no extra cost or work, and it ensures that workers knowledge is captured in sequential order. This approach is, however, limited by cost and openness due to the absence of privacy.

- Audio recording

This technology is already in use but not for this task yet.

A lot of workers wear ear pods to communicate among themselves, but the idea of recording their speech is not considered.

Our idea is to use this spreading technology to acquire valuable information that guarantees knowledge sustainability from experienced employees.

The innovation in this approach is how we intend to utilize the technology. Recording employees to track their work, gestures, behavior, and performance during work activities is faster, and no additional work is required. This provided a grid/structured arrangement for knowledge acquisition.

Costs, however, remain the main problem of these techniques.

- Kinect

Kinect, known by the code name of Project Natal, is an accessory developed by Microsoft for the Xbox 360 console, sensitive to human movement. Kinect can be used to trace human body movements to identify micro-actions that can be saved and associated with specified tasks. The cost required for this solution is a bit high and thus may not be suitable in most cases, especially when there is financial limitation

6. Conclusion

In every developing economy, organizations rely on technology and knowledge to gain a competitive advantage over others. In such scenarios, companies should be constantly careful of external changes that might positively or negatively affect their activities. To achieve this, most organizations need to cope with changes in their available resources, which depend on the organization's size.In this kind of market, small and medium-sized enterprises need to be more conversant with changes that might force them into extinction, as they have limited financial capital and human resources. To achieve this, resources audit, maintenance and management are important, particularly when it involves human knowledge and experience, as this varies significantly among workers/employees. Employee knowledge and experience gives an organization a comparative advantage over its competitors. If this is lost, such that it becomes irretrievable, the organization might lose this advantage which in turn affects it cooperate strategy adversely, and eventually, might prevent the organization from achieving its operational, tactical, and strategic goals. For this reason, it is the organization responsible for ensuring that such resources are retained and stored in their armory.

This research work addressed this problem by developing a tool for supporting management activities during knowledge acquisition, processing and storing. It achieved this by proposing a systematic procedure that aids management decision in choosing the best knowledge elicitation techniques for workers during their regular activities. This work later focused on assembly and maintenance processes to justify the performance of the developed tool. The tool is inexpensive (affordable to SME's), user-friendly, and best provides knowledge eliciting techniques that will not increase workers' activities during operation. It is designed using tools from Microsoft Excel, which is readily available in the Microsoft Office package and as a significant contribution, the proposed *"AHP & PIE for KAS"* model integrate knowledge management, knowledge acquisition and knowledge digitization for small and medium-sized enterprise as demonstrated in the maintenance and assembly processes described in Section 4 above.

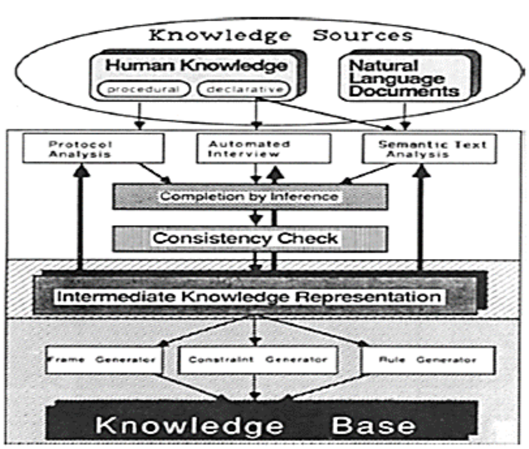

Figure 11. Kriton structure.

Conflict of interest

All authors contributed in
(1) Problem definition and analysis,
(2) article writing and revising

This authors further confirmed that the manuscript has not been submitted to any other Journal.

Acknowledgements

We thank the reviewers for the time and effort they took to review the manuscript, and we appreciate their criticisms. We greatly appreciate their insightful criticism and advice, which helped us to improve the work.

Funding

The authors did not receive any financial support for this work.

References

Alonso, J. A., & Lamata, M. T. (2006). Consistency in the analytic hierarchy process: a new approach. *International journal of uncertainty, fuzziness and knowledge-based systems*, *14*(04), 445-459.
https://doi.org/10.1142/S0218488506004114

Asher, D., & Popper, M. (2019). Tacit knowledge as a multilayer phenomenon: the "onion" model. *The Learning Organization*, *26*(3), 264-275.
https://doi.org/10.1108/TLO-06-2018-0105

Baporikar, N. (2020). Learning link in organizational tacit knowledge creation and dissemination. *International Journal of Sociotechnology and Knowledge Development (IJSKD)*, *12*(4), 70-88.
https://doi.org/10.4018/IJSKD.2020100105

Barcelo-Valenzuela, M., Carrillo-Villafaña, P. S., Perez-Soltero, A., & Sanchez-Schmitz, G. (2016). A framework to acquire explicit knowledge stored on different versions of software. *Information and Software Technology*, *70*, 40-48.
https://doi.org/10.1016/j.infsof.2015.09.007

Bolade, S., & Sindakis, S. (2020). Micro-foundation of knowledge creation theory: Development of a conceptual framework theory. *Journal of the Knowledge Economy*, *11*(4), 1556-1572.
https://doi.org/10.1007/s13132-019-00623-2

Bratianu, C. (Ed.). (2015). Organizational knowledge dynamics: Managing knowledge creation, acquisition, sharing, and transformation: Managing knowledge creation, acquisition, sharing, and transformation. IGI Global.

Chergui, W., Zidat, S., & Marir, F. (2020). An approach to the acquisition of tacit knowledge based on an ontological model. *Journal of King Saud University-computer and information sciences*, *32*(7), 818-828. https://doi.org/10.1016/j.jksuci.2018.09.012

Cooke, N. J. (1994). Varieties of knowledge elicitation techniques. *International journal of human-computer studies*, *41*(6), 801-849. https://doi.org/10.1006/ijhc.1994.1083

Desouza, K. C., & Awazu, Y. (2006). Knowledge management at SMEs: five peculiarities. *Journal of knowledge management*, *10*(1), 32-43. https://doi.org/10.1108/13673270610650085

Diederich, J., Ruhmann, I., & May, M. (1987). KRITON: a knowledge-acquisition tool for expert systems. *International Journal of Man-Machine Studies*, *26*(1), 29-40. https://doi.org/10.1016/S0020-7373(87)80033-0

El-Den, J., & Sriratanaviriyakul, N. (2019). The role of opinions and ideas as types of tacit knowledge. *Procedia Computer Science*, *161*, 23-31. https://doi.org/10.1016/j.procs.2019.11.095

García-Sánchez, E., García-Morales, V. J., & Bolívar-Ramos, M. T. (2017). The influence of top management support for ICTs on organisational performance through knowledge acquisition, transfer, and utilisation. *Review of Managerial Science*, *11*, 19-51. https://doi.org/10.1007/s11846-015-0179-3

Gavrilova, T., & Andreeva, T. (2012). Knowledge elicitation techniques in a knowledge management context. Journal of Knowledge Management, *16*(4), 523-537. https://doi.org/10.1108/13673271211246112

Hanafizadeh, P., & Ghamkhari, F. (2019). Elicitation of tacit knowledge using soft systems methodology. *Systemic Practice and Action Research*, *32*(5), 521-555. https://doi.org/10.1007/s11213-018-9472-9

Harteis, C. (2018). The Impact of Digitalization in the Workplace: An Educational View. Professional and Practice-Based Learning. Volume 21. *Professional and Practice-based Learning*. https://doi.org/10.1007/978-3-319-63257-5

Henard, D. H., & McFadyen, M. A. (2006). R&D knowledge is power. Research-Technology Management, 49(3), 41-47.

Hoffman, R. R., Shadbolt, N. R., Burton, A. M., & Klein, G. (1995). Eliciting knowledge from experts: A methodological analysis. *Organizational behavior and human decision processes*, *62*(2), 129-158. https://doi.org/10.1006/obhd.1995.1039

Ibidunni, A. S. (2020). Exploring knowledge dimensions for improving performance in organizations. *Journal of Workplace Learning*, *32*(1), 76-93. https://doi.org/10.1108/JWL-01-2019-0013

Irani, Z., Sharif, A. M., & Love, P. E. (2009). Mapping knowledge management and organizational learning in support of organizational memory. *International Journal of Production Economics*, *122*(1), 200-215. https://doi.org/10.1016/j.ijpe.2009.05.020

Jha, R. S., & Sahoo, P. R. (2021). Influence of big data capabilities in knowledge management—MSMEs. In *ICT Systems and Sustainability: Proceedings of ICT4SD 2020, Volume 1* (pp. 513-524). Springer Singapore. https://doi.org/10.1007/978-981-15-8289-9_50

Johnson, M. P. (2017). Knowledge acquisition and development in sustainability-oriented small and medium-sized enterprises: Exploring the practices, capabilities and cooperation. *Journal of cleaner production*, *142*, 3769-3781. https://doi.org/10.1016/j.jclepro.2016.10.087

Letmathe, P., & Rößler, M. (2019). Tacit knowledge transfer and spillover learning in ramp-ups. *International Journal of Operations & Production Management*, *39*(9/10), 1099-1121. https://doi.org/10.18154/RWTH-2019-11928

Leu, G., & Abbass, H. (2016). A multi-disciplinary review of knowledge acquisition methods: From human to autonomous eliciting agents. *Knowledge-Based Systems*, *105*, 1-22. https://doi.org/10.1016/j.knosys.2016.02.012

Maruta, R. (2012). Transforming knowledge workers into innovation workers to improve corporate productivity. *Knowledge-Based Systems*, *30*, 35-47. https://doi.org/10.1016/j.knosys.2011.06.017

Mittal, S., & Kumar, V. (2019). Study of knowledge management models and their relevance in organisations. *International Journal of Knowledge Management Studies*, *10*(3), 322-335. https://doi.org/10.1504/IJKMS.2019.101491

Moody, J. W., Blanton, J. E., & Will, R. P. (1999). Capturing expertise from experts: The need to match knowledge elicitation techniques with expert system types. *Journal of Computer Information Systems*, *39*(2), 89-95. https://doi.org/10.1080/08874417.1999.11647396

Müller, E., & Hopf, H. (2017). Competence center for the digital transformation in small and medium-sized enterprises. *Procedia Manufacturing*, *11*, 1495-1500. https://doi.org/10.1016/j.promfg.2017.07.281

Baptista Nunes, M., Annansingh, F., Eaglestone, B., & Wakefield, R. (2006). Knowledge management issues in knowledge-intensive SMEs. *Journal of documentation*, *62*(1), 101-119. https://doi.org/10.1108/00220410610642075

Oyefolahan, O. I., & Dominic, P. D. D. (2013). Knowledge management systems use and competency development among knowledge workers: the role of socio-technical antecedents in developing autonomous motivation to use. *VINE: The journal of information and knowledge management systems*, *43*(4), 482-500. https://doi.org/10.1108/VINE-07-2012-0023

Roth, E. M., O'Hara, J., Bisantz, A., Endsley, M. R., Hoffman, R., Klein, G., ... & Pfautz, J. D. (2014). Discussion panel: how to recognize a "good" cognitive task analysis?. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 58, No. 1, pp. 320-324). Sage CA: Los Angeles, CA: SAGE Publications. https://doi.org/10.1177/1541931214581066

Salehi, A., & Izadikhah, M. (2014). A novel method to extend SAW for decision-making problems with interval data. Decision Science Letters, 3(2), 225-236.

Saaty, T. L. (1984). The analytic hierarchy process: Decision making in complex environments. In *Quantitative assessment in arms control: mathematical modeling and simulation in the analysis of arms control problems* (pp. 285-308). Boston, MA: Springer US. https://doi.org/10.1007/978-1-4613-2805-6_12

Vukašinović, N., Vasić, D., & Tavčar, J. (2018). Application of knowledge management system to injection mold design and manufacturing in small enterprises. In *DS 92: Proceedings of the DESIGN 2018 15th International Design Conference* (pp. 1733-1744). https://doi.org/10.21278/idc.2018.0160