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PRACTICAL APPLICATION OF THE KNOWLEDGE TRANSFER EMS (EXCHANGE OF MENTAL SCHEMES) METHODOLOGY TO INDUSTRIAL ENVIRONMENT

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ABSTRACT
The need of knowledge transfer within an organisation, not only explicit knowledge but also tacit knowledge, is a necessary premise to improve overall efficiency. The transmission of explicit knowledge tends to be an easier task, by means of, for example, IT-based KM applications, mostly despite the fact that employees do need information from others in order to carry out their daily work. Encouraging tacit knowledge transfer between them is a more difficult activity not usually performed in a spontaneous way in the industrial environment. Methodologies to facilitate it are also not commonly found in the literature.
This study involves an application of the EMS (Exchange of Mental Schemes) methodology to the industrial environment, in a production process design area of a large company. Five designers have carried out EMS sessions to analyse four different concepts/activities of their daily work. The obtained results, not only through comparison between pre-test and pos-test, but also by means of a protocol analysis of the video-recorded sessions, have shown a clearly positive tendency to improve knowledge transmission between them.
Designers' personal opinions also fit in with the obtained results: EMS is regarded as an applicable method that can help not only to understand better those concepts related to their daily work, by learning other points of view, but also to avoid loss of individual knowledge. Also, a benefit improving the relationship between them is considered an additional advantage by the participants in these practical sessions, being defined in the literature as a crucial premise to encourage transfer of tacit knowledge.

Keywords: Knowledge transfer; EMS methodology; industrial environment; protocol analysis

1 INTRODUCTION
Knowledge transfer, especially transfer of tacit knowledge, between different people of an organisation is a difficult task that often presents, in practice, important deficiencies (eg. lack of time, sharing one's knowledge is sometimes seen as a loss of power, or other management priorities). Despite being able to find premises in the literature to encourage this type of knowledge transfer, it is very difficult to find knowledge management applications or methodologies to facilitate it in the industrial environment.
EMS [1], based on exchange and transmission of knowledge among different people of a group, has been proved to be a valid methodology to improve engineering concepts learned at university. Its application in the industrial environment will help to encourage tacit knowledge transfer among employees.

2 OBJECTIVES
The aim of this article is the application of the EMS methodology in the Production Process Design Department of a major company in order to prove better transmission of knowledge between the area's human capital and, therefore, an increase in the global knowledge of the group.

The analysis of this practical application will be carried out through:

- Analysis of the results by means of comparison between pre-test and post-test.
- Protocol analysis [2] of the experimental sessions.

Finally, the results obtained in the industrial environment will be verified, claiming the same tendency as in the results obtained in the practical application at University (School of Industrial Engineers of Barcelona (ETSEIB)/Technical University of Catalonia), where the EMS methodology has been statistically validated.

3 STATE-OF-THE-ART

3.1 Knowledge Management applications

Knowledge Management (KM) is a term used to name very different activities, depending mainly on the way the word knowledge is understood. Knowledge may be viewed from several perspectives: a state of mind, an object, a process, a condition of having access to information, a capability or even usually understood as a synonym of information. Based on these different perspectives, the term Knowledge Management has very different implications and some possible applications (Table 1).

Table 1. Knowledge Perspectives and Their Implications [3]

Perspectives		**Implications for Knowledge Management (KM)**	**Implications for Knowledge Management Systems (KMS)**
Knowledge vis-à-vis data and information	Data are facts, raw numbers. Information is processed / interpreted data. Knowledge is personalised information.	KM focuses on exposing individuals to potentially useful information and facilitating assimilation of information.	KMS will not appear radically different from existing Information Systems (IS), but it will be extended toward helping in user assimilation of information.
State of mind	Knowledge is the state of knowing and understanding.	KM involves enhancing an individual's learning and understanding through provision of information.	Role of Information Technology (IT) is to provide access to sources of knowledge rather than knowledge itself.
Object	Knowledge is an object to be stored and manipulated.	Key KM issue is building and managing knowledge stocks.	Role of IT involves gathering, storing and transferring knowledge.
Process	Knowledge is a process of applying expertise.	KM focus is on knowledge flows and the process of creation, sharing and distributing knowledge.	Role of IT is to provide link among sources of knowledge to create wider breadth and depth of knowledge flows.
Access to information	Knowledge is a condition of access to information.	KM focus is organised access to and retrieval of content.	Role of IT is to provide effective search and retrieval mechanisms for locating relevant information.
Capability	Knowledge is the potential to influence action.	KM is about building core competencies and understanding strategic know-how.	Role of IT is to enhance intellectual capital by supporting development of individual and organisational competencies.

Knowledge can also be understood as being tacit or explicit [4-5]. Tacit knowledge, defined as 'we know more than we can tell' by Polanyi [4], can, as well, be divided into cognitive (an individual's mental models consisting of mental maps, beliefs, paradigms and viewpoints) or technical (concrete know-how, crafts, and skills that apply to a specific context). An intermediate category between tacit and explicit is also presented by other authors: implicit knowledge is defined as knowledge that is tacit in form, but is accessible through querying and discussion [6].

Another dimension of knowledge that can be found in the literature is the individual, created by and existing in the individual, or the collective dimension, created by and inherent in the collective actions of a group[5].

Most KM applications are supported by Knowledge Management Systems (KMS), a class of information systems applied to managing organisational knowledge. These tools are based on Information Technology (IT) and have been developed to support the creation, access, storage/retrieval and application of knowledge within an organisation.
To date, KM applications have been introduced and carried out in large companies, in order to support the large amount of information currently generated by any organisation. Project information storage or retrieval, providing access to sources of knowledge, and effective search mechanisms for locating relevant information are some examples of these applications' possibilities. Explicit collective and even individual knowledge are then easily represented in such applications but creating, transferring or storing tacit individual knowledge are not an easy task.
The basic conditions for tacit knowledge to be created, shared and used are interaction with others, personal contact and trust among organisation members [7-9]. Much tacit knowledge is generated and transferred through body language or physical demonstration of skills and, therefore, the use of information and communication technology is only partly possible [10]. When adding other factors, usually found in large organisations, such as lack of time or even lack of motivation, the transfer of tacit individual knowledge becomes very difficult through IT-based KM applications.
A popular technique for capitalising on the respective insights and intuitions (tacit knowledge) of a group of individuals is to conduct brainstorming sessions, normally used in creation or innovation activities.
On the other hand, it is difficult to find in the literature methodologies to support tacit knowledge transfer process: the "Transition Alliance" initiated by Xerox (individuals rewarded for hoarding their tacit knowledge) [11] is one of few examples.

However the premises to encourage the tacit knowledge transfer in organisations have been widely defined in the literature [11-12]. Some important points follow:

- Sharing tacit knowledge will be more successful in informal settings than in formal ones.
- It is important for the management of organisations to cultivate commitment to motivate the sharing of tacit knowledge, and to create an atmosphere in which an organisation's members feel safe sharing their knowledge.
- Management should also create a working environment which supports respect for different thinking styles without penalties for failure, thus encouraging an open culture.
- The closeness of the employees is the key to the degree of tacit knowledge transferred.
- Tacit knowledge is usually transferred through body language or physical demonstration of skills.
- The factor of 'lack of time', very common in organisations, should be taken into account in order to reduce its impact on tacit knowledge transfer.

3.2 The EMS methodology

The EMS methodology is a method that was developed in the university environment to improve the learning process with regard to engineering concepts and to induce a more deep and long-term learning. Its basis was an evolution of the self-explanation technique [13-14], applied in group, in order to facilitate the exchange of mental maps between engineering students concerning a given concept. Its aim was to exchange not only explic it knowledge but also tacit knowledge, in order to complete, correct or even modify the mental schemes of the participants regarding the given concept. The results obtained in the statistical validation process of this methodology can be seen in Table 2.
Its application in the industrial environment has been proposed in order to encourage the knowledge transfer between people belonging to a same department.
The basic principles of this methodology are the following (the detailed explanation of the different phases of the methodology can be found in previous articles [1]):

- There is an explanation of all the people of the group in order to express his/her mental scheme regarding a given concept/activity/task.
- This explanation is accompanied by an active listening by the other members of the group and the opening of minds, as much as possible, to try to understand other people's mental schemes.
- There is feedback generation within the group in order to deeply understand what the other people are trying to express, making as many comments as possible, as well as reflections, with regard to the concepts expressed by the other people (maximum interaction).

- The participants can use the resources they consider necessary, such as metaphors, comparisons or drafts. If considered opportune, exaggerations or ideas that might appear to lack any basis should help to express their way of thinking with regard to a given concept.
- There are no nonsense affirmations: every opinion/idea/mental map can help to complete/extend/modify the own mental scheme. Nobody must be permitted to laugh at anyone else in the group, as happens in brainstorming.
- The results of these sessions must not elevate to management. What is sought here is that these people will be able to apply the methodology in a relaxed way without feeling inhibited.
- A fixed schedule to carry out a knowledge transfer EMS session must be established and always be respected by management.

Table 2. Validation of the EMS methodology

<table>
<tr><td rowspan="2">Practical experimentation and statistical validation by comparing two treatments</td><td>Treatment or method A</td><td>Carrying out the EMS method for a specific concept</td></tr>
<tr><td>Treatment or method B</td><td>Not carrying out the EMS method for a specific concept but carrying out the usual individual study</td></tr>
<tr><td rowspan="2">Analysed concepts</td><td colspan="2">Four-stroke combustion engine</td></tr>
<tr><td colspan="2">Hybrid engine</td></tr>
<tr><td>Participants</td><td colspan="2">Fifth-year engineering students of the Superior Technical University of Industrial Engineers of Barcelona – Technical University of Catalonia</td></tr>
<tr><td>Sample size</td><td colspan="2">60 participants</td></tr>
<tr><td>Material</td><td colspan="2">Externalisation of the Mental Scheme Form (EMSF)</td></tr>
<tr><td rowspan="3">Parameters analysed</td><td colspan="2">Number of basic sub-concepts per person (SC_b)</td></tr>
<tr><td colspan="2">Number of erroneous sub-concepts (SC_e)</td></tr>
<tr><td colspan="2">Number of basic sub-concepts weighted by the level of coincidence (shared sub-concepts) among the different persons in the group ($VPSC_b$)
$$VPSC_b = \sum_{n=1}^{5} SC_{bn} \cdot 2^{(n-1)}$$</td></tr>
<tr><td>Statistical analysis</td><td>Three null hypotheses and three alternative hypotheses were therefore considered, one to analyse each of the three parameters.</td><td>These three hypotheses were contrasted using the findings obtained in the experiment.

The EMS methodology provides a significant advantage for learning concepts if the three alternative hypotheses can be stated with a sufficiently high degree of certainty.</td></tr>
<tr><td>Obtained results</td><td colspan="2">The three premises were fulfilled with a very high degree of certainty
(> 95 % statistical certainty)</td></tr>
<tr><td colspan="3">Based on these findings, it was therefore stated that by applying EMS methodology, satisfactory results were achieved that were noticeably better than with conventional study.</td></tr>
</table>

Due to its characteristics, the application of this methodology in industrial organisations could help to encourage knowledge transfer between peers, especially tacit knowledge transfer, filling the existing gap concerning this type of knowledge transmission within organisations.

4 METHODOLOGY

4.1 Practical application

The practical application of the EMS methodology in an industrial environment has been carried out with a group of five productive process designers of a big company.

The choice of these people has been done without a definite pattern, every designer being responsible for a different production process.

The following steps have been carried out:

- Participants' authorisation request.
- Determination of the concepts/activities/tasks of the designers' daily work to be analysed with the EMS methodology application:

  The best way to know which core concepts/activities of a production process designer's daily work are is to ask each of them to make a list with the concepts/ideas they think are essential for their work.

  Based on the results obtained, four different concepts/activities, mentioned by all participants, have been chosen: (1) installation electricity concepts; (2) product definition; (3) union techniques; (4) management of a habitual situation: put into operation of an installation and first preliminary series.
- Pre-test: individual externalisation of the own mental scheme regarding the chosen concepts.

  All five participants have been asked to externalise their own mental scheme about the four given concepts/activities individually. For this purpose, an externalisation pre-established form has been used (EMSF [1]). It is known that the expression or externalisation of one's own mental scheme is a very difficult, or even impossible, process and that the means used to do so may affect the idea we have in our minds. It is also difficult to know exactly what the idea or scheme is that we have in our minds. The aim of the form is to help the participants to express their own idea or scheme with as few limitations or restrictions as possible. That is why the form has to be merely a guideline, minimally influencing the externalisation of the mental scheme.

  The time allocated for this process has been flexible: it depended on each person, allowing them to finish in their own time.
- Explanation of the EMS methodology to the group: first, written information with the methodology's phases and their characteristics has been given, as well as time to read it. An oral explanation in group has been then carried out. Finally, a card with a schema of the methodology has been given to the participants in order to consult it, when needed, during the EMS application session.
- Application in group of the EMS methodology to the chosen concepts.

  Four different EMS sessions have been carried out, one each of the four different concepts. These sessions have been video-recoded in order to analyse the process itself through a protocol analysis.
- Post-test: individual externalisation of the own mental scheme after the application of the EMS experiment.

  After the methodology application, a post-test has been carried out in order to compare the externalisation forms (EMSF) obtained before and after the EMS session.

  As it has been done with the pre-test externalisation, each participant has had his/her own time to finish the task.
- Questionnaire related to the experiences of every member of the group taking part in these EMS sessions.

  As a final point, it is important to get to know the sensations felt by each of the people taking part in this exercise, with regard to the benefits obtained. The fact of any future use will depend, absolutely, on the specific desire of each one of them. They will only apply themselves to this system in a natural way, without impositions, if they think it is a practice that makes sense.

4.2 Parameters used to compare pre-test and post-test

The parameters used to compare pre-test and post-test are the same used for the validation of the EMS methodology in the university environment. These are:

- Number of basic sub-concepts per person (SC_b), understanding as a sub-concept each of the independent parts into which a concept can be divided. The aim here is the meaning of each of these units and not its form.
  In the university environment application, it is said that if a person is capable of explaining the basic points or the nub of a concept, those aspects without which the basic concept would not be complete, then it is assumed that the degree of learning has been reasonably good.
  When adapting this same parameter to the knowledge transfer process in the industrial environment, it could be said that:
    - If the number of correct basic sub-concepts externalised by a given person in the post-test is greater than in the pre-test, it is assumed that his/her mental scheme has been completed, probably due to the transmission of knowledge of other people of the group and/or by the reflection process when externalising his/her own mental scheme.
    - If the total number of correct basic sub-concepts externalised by the group in the post-test is greater than in the pre-test, it is assumed that the knowledge of the group has improved, probably due to the reflection process carried out when combining different mental schemes.
- Number of rejected sub-concepts (SC_r): Sub-concepts that have been rejected after the application of the EMS methodology.
  In the university environment, this parameter was named "Number of erroneous sub-concepts": when talking about engineering concepts, it is easier to determine if a given idea is erroneous or not. When a person's explanation concerning a specific concept does not contain erroneous statements it is then associated to good learning.
  In the industrial case, it is only said that a sub-concept is rejected or not during the EMS session by a given person, probably due to the transmission of knowledge of other people of the group and/or by the reflection process when externalising his/her own mental scheme.
- Shared sub-concepts (basic sub-concepts weighted by the level of coincidence) ($VPSC_b$):
  This last parameter prioritises those basic concepts that have been named by various people in the group compared with individual basic sub-concepts, named by just one person, or shared by only a few people in the group. It is understood that knowledge transmission process has been carried out efficiently when different people understand the same thing by this concept and can carry out joint reasoning.

$$VPSC_b = \sum_{n=1}^{5} SC_{bn} \cdot 2^{(n-1)} \quad (1)$$

  Base 2 was proposed for the weighting in this investigation after a sensitivity analysis [1].

4.3 Codification of the video-recorded sessions - Protocol analysis

Finally, in order to carry out the protocol analysis of the video-recorded application, a transcription and codification of the EMS sessions have been performed: every verbalisation pronounced by each of the five participants has been codified, the time it was verbalised and the relationship between the explanations that proceed and follow it (Table 3). The affirmation and negation gestures have also been codified.

The nomenclature used is the following:

Explanation:

$\mathbf{E_I}$	Individual explanation
$\mathbf{E_E}$	Extension of a previous explanation
$\mathbf{E_{EP}}$	Extension of an own previous explanation
$\mathbf{E_{EO}}$	Extension of a previous explanation of another person of the group

Feedback:

$\mathbf{F_A}$	Affirmative feedback ($\mathbf{F_{AG}}$ - gesture of affirmation)
$\mathbf{F_N}$	Negative feedback ($\mathbf{F_{NG}}$ - gesture of negation)
$\mathbf{F_D}$	Feedback of doubt
Q	Question

Final conclusion / summary:

S Summary

Links between different verbalising objects represent the chronological sequence.
In order to visualise the main ideas' flow, every verbalisation related to a same idea or sub-concept is codified with a number representing it (Table 4).

Table 3. Protocol analysis: transcription schema of an EMS session

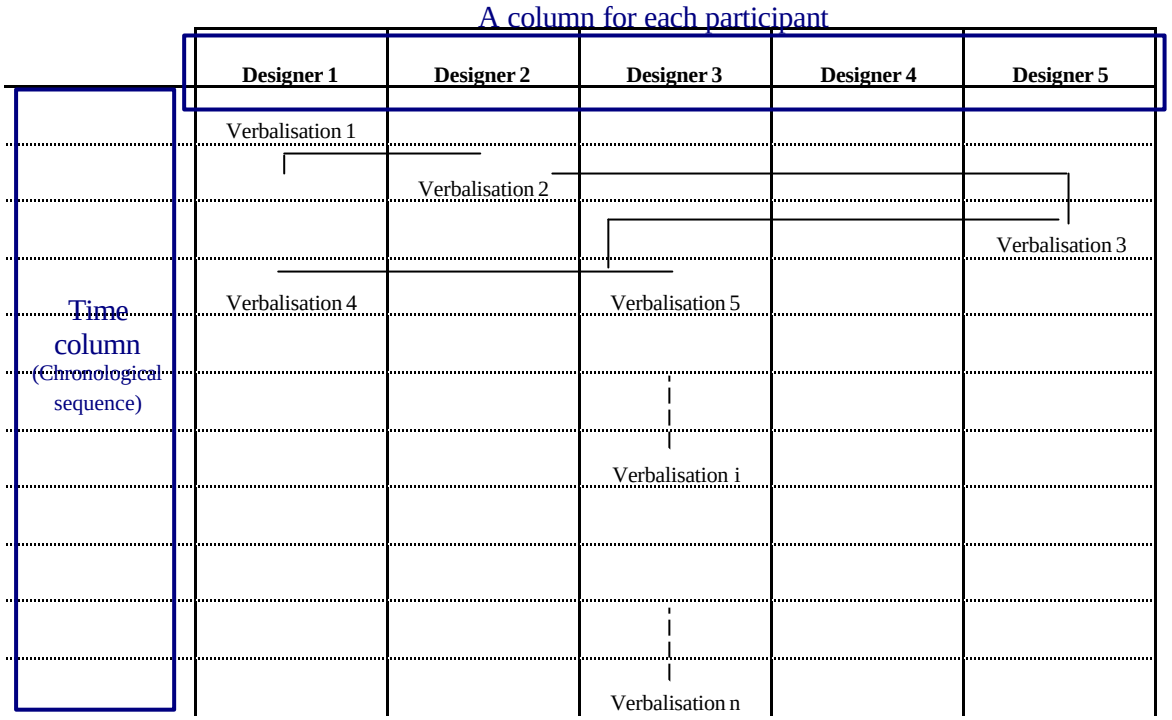

Table 4. Protocol analysis: example of a transcription (idea/sub-concept "1")

	Designer 1	Designer 2	Designer 3	Designer 4	Designer 5
00:00	E_I - 1				
00:04		F_D - 1			
00:04		Q – 1			
00:05	E_{EP} - 1				

5 RESULTS

The obtained results are explained in the two following points: the comparison between pre-test and post-test in the first one, and the outcomes and conclusions of the protocol analysis in the second one. Additionally, the analysis of the personal opinion of every participant about the proposed methodology is presented. Its success of the application in the industry will depend mainly on the benefits that the participants experience. Therefore, this last point has special relevance.

5.1 Comparison between pre-test and post-test: obtained results

As explained above, three parameters have been analysed before and after the EMS session. The final idea is to compare some figures that could give us an idea of what could be named as "level of knowledge". These parameters are: SC_b, SC_r and $VPSC_b$.

The obtained results are the following (Table 5, 6 and 7):

Table 5. Parameter 1: SC_b (Number of basic sub-concepts)

	Concept 1		**Concept 2**		**Concept 3**		**Concept 4**	
	Pre-test	Post -test	Pre-test	Post -test	Pre-test	Post -test	Pre-test	Post -test
Designer 1	3	5	3	5	4	4	4	12
Designer 2	3	4	4	5	3	4	3	6
Designer 3	1	6	3	3	1	4	1	9
Designer 4	2	5	2	4	2	4	1	7
Designer 5	1	4	3	3	2	3	3	8
AVERAGE	**2,0**	**4,0**	**3,0**	**4,0**	**2,4**	**3,8**	**2,4**	**8,4**
Ratio	2,0		1,3		1,6		3,5	

Table 6. Parameter 2: SCr (Number of rejected sub-concepts)

	Concept 1	**Concept 2**	**Concept 3**	**Concept 4**
Designer 1	1			
Designer 2				
Designer 3			1	1
Designer 4		1		
Designer 5	3			1
TOTAL	**4**	**1**	**1**	**2**

Table 7. Parameter 3: VPSCb (shared sub-concepts)

	Concept 1		**Concept 2**		**Concept 3**		**Concept 4**	
	Pre-test	Post -test	Pre-test	Post -test	Pre-test	Post -test	Pre-test	Post -test
$VPSC_b$	**13**	**46**	**26**	**44**	**15**	**42**	**23**	**91**
Ratio	3,5		1,7		2,8		4,0	

Additionally, it has been observed that many concepts have been extended during the session's process, but counted in the above parameters with the same value in both, the pre-test and post-test. For this reason, a new parameter has been defined: the number of times a sub-concept has been extended or completed (Table 8).

Table 8. Total number of times sub-concepts that have been extended per designer

	Concept 1	Concept 2	Concept 3	Concept 4
Designer 1	4	6	2	7
Designer 2	1	5	2	6
Designer 3	1	6	1	4
Designer 4	7	5	3	1
Designer 5	1	1	2	2
TOTAL	**15**	**23**	**10**	**20**
Ratio	3,0	4,6	2,0	4,0

Analysing the values associated at every parameter, we may conclude that:

- The number of basic sub-concepts has increased in all four cases, even not having considered the fact that many sub-concepts externalised in the post-test have been extended during the EMS session. For example, the ability to obtain all the *relevant* product information for the production process are basic sub-concepts shared during one of the four sessions.
- In all four cases, there have been sub-concepts that have been rejected during the EMS session. An example of rejected sub-concept is not being able to influence product-definition-timing and avoid information delay.
- The value associated to the shared sub-concepts between the designers has also clearly increased in all four experiments.

Although the numerical results obtained in all four processes are not comparable, because of the different nature of each concept, the three parameters have the same tendency in all of them. This observed tendency agrees with the obtained results in the university environment (an increase of SC_b, no SC_e after the session, and an increase of $VPSC_b$) [1].

It can be concluded that the mental schemes of the people participating in this investigation seem to have been completed (i.e. more sub-concepts have been externalised), corrected (i.e. some sub-concepts have been rejected in a natural way during the session) and have become more similar to the ones of their peers. Therefore, we will assume that a transfer of knowledge process has been carried out among them.

5.2 Protocol analysis

In order to analyse the EMS sessions' process, the transcriptions of all the verbalisations and gesture affirmations and negations have been carried out, identifying the designer and the moment of the verbalisation or gesture. An Excel file has been used for this purpose, recording each sentence in a different row. Time and designer number have been recorded in the two preceding columns.

The identification of sub-concepts and type of verbalisation, such as individual explanation, extended explanation or affirmative feedback, has been the second step.

Finally, the obtained information has been rearranged in the format explained in the section above (Table 3).

After detailed observation of the obtained structures with the process transcription, the main conclusions are:

- There is feedback generation: affirmative and negative feedback followed by a personal opinion/mental scheme, but also questions are asked to better understand others' points of view.
- There is an evolution of the different explained ideas due to the feedback/communication between the designers. Most explained ideas at the end of the sessions have been also presented at the beginning but in a simpler way. For example, there was a clear evolution of the concept of determination of the viability of union techniques in product definition.

- Most rejected ideas have been turned down after an interaction process between the people of the group. In only one case, the person explaining his own mental scheme has realised, by himself, that there was an erroneous aspect in his explanation. As an example, a personal insight into a business trip to another automobile production company was explained to express the importance of welding in automobile manufacturing.
- New ideas, not externalised in the pre-test, have arisen. The origin has been mainly the ideas explained by others. Combinations of simple and apparently interconnected ideas have also been created.
- In some cases, anecdotes or specific personal experiences have been explained to help to express a personal point of view or mental scheme.
- In three of the four cases, a conclusion of the main ideas has derived from one of the participants.
- Language gesture has also been used often to express one's points of view.

Time consumed to analyze every concept was unexpectedly short: not more that nine minutes per concept. The non-conflictive nature of the chosen concepts will probably be the cause. However, it is expected, depending on the nature of the analyzed concepts, that the time needed for an EMS session will increase.

As an example, the first fragment of the protocol analysis of one of the concepts has been represented in Table 9.

Table 9. Protocol analysis: transcription of the first 3:21 minutes of concept number 4

	Designer 1	Designer 2	Designer 3	Designer 4	Designer 5
0:00	E_I - 1				
0:15	E_I - 2				
0:18	E_E - 2				
0:25	E_I - 3				
0:28	E_I - 4				
0:34	E_E - 1				
0:40			E_I - 6		
0:55	F_N - 6				
0:56	E_I - 7 (= NO 6)				
0:56			F_{AG} - 7 (= NO 6)		
1:00	E_I - 8				
1:20			F_A - 8		
1:38		E_E - 1			
1:43		E_E - 7			
1:45		E_E - 7			
1:58		E_I - 2			
2:04		E_I - 4			
2:15	E_E - 8				
2:40			E_E - 2		
2:46			E_E - 1		
2:48				E_I - 2	
2:49				E_I - 4	
2:50			E_E - 8		
2:54	Q 3				
2:59	E_E - 3				
3:00				F_A - 3	
3:02	Q 4				
3:06	E_E - 4				
3:12				F_D - 4	
3:14				E_I - 2	
3:16					E_I - 1
3:18					E_I - 2
3:21			E_I - 1		

5.3 Designer personal opinion

After analysing the personal opinion questionnaries, the main conclusions obtained are the following:

- The designers felt comfortable during the EMS sessions. The methodology technique has also been easy to apply.

- The designers believe that they have learnt new ideas and points of view to apply in their daily work and that their own concepts have been clarified.
- The designers also consider that the proposed methodology could be regularly applied in the analysed area. Some of the reasons put forth are: not to lose the knowledge of the people in the department, to learn how other people solve the same kind of problems or used to reflect on their mental schemes.
- Other possible benefits of this methodology proposed by the designers are to improve the relationship between the people of the department and to unify the area criteria.
- Finally, following the designers' advice, more conflictive or critical concepts should be addressed in order to obtain greater benefit from each session.

6 CONCLUSIONS

Methodologies to support tacit knowledge transfer in organisations, especially in industrial environments, are not commonly found in the literature. However the premises to encourage it have been widely defined. The EMS methodology, first developed in a university setting to improve learning of engineering concepts, fulfils most of them.

The practical application of the EMS methodology in a given company, to a group of five production process designers has succeeded in improving the parameters associated to the level of knowledge, not only of each designer, but to knowledge of the entire analysed group (results obtained by means of comparison between pre-test and post-test and by protocol analysis).

The designers' personal opinions are also very positive, thus being the key for the EMS methodology application to succeed in the day-to-day work of the area. Another basic requirement is management implication: among other premises, the ability to respect scheduled sessions, refraining from participating or attempting to discover results or conclusions of the sessions in order to allow their employees to participate without feeling inhibited.

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