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Reinforcement the Learning of Topics of Manufacturing Systems by Playing Through Theater Personages*

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This paper deals with a method of learning through play for the reinforcement of knowledge and concepts. The act of playing occurs within plays of theater, created by learners, using analogies and metaphors that aim to match technical concepts with situations of the play through dialogues. Students learn through play in different moments of the learning process: during the task of creating the play by looking for funny dialogues and situations where the metaphors and analogies should match with technical concepts; while students are designing the wardrobe and the stage; and when the performance of the play takes place. Creativity of learners is exploited resulting in an improvement of retention of concepts around the topics to be reinforced. This method has been successfully applied in our institution since 2006, for the reinforcement of topics belonging to the course of Integrated Manufacturing Systems in Undergraduate Engineering Programs. In order to asses quantitatively the efficiency of the method in the retention and understanding of concepts two tests have been made before and after the application of the method.

Keywords: learning; play; analogies; metaphors

1. Introduction

One of the main activities during the process of learning is to reinforce the knowledge being acquired. Frequently, students forget relevant concepts that they have learned. It could be due to the lack of motivation related with the learning process because traditional methods do not encourage challenge to exploit the creative capabilities of the students. This work deals with a motivating method that uses plays of theater to aid students to retain concepts of topics. The next paragraphs deal with relevant works related with the learning through play method. Given that the method of learning through play, proposed in the present work, turns around analogies and metaphors as the main concepts that entail the learning process through play, a set of relevant works using these techniques in the learning process are also exposed.

1.1 Related works

Most of the techniques related with learning through play are applied in the children context [1–3]. Studies about the impact of video games and simulations can be found in [4–5]. For unknown reasons the technique of learning through play is rarely applied in higher education, particularly in engineering programs. One of the reasons could be that engineering programs require, usually, formal approaches for explaining concepts used to solve technical problems. On the contrary, the fact of playing is apparently informal, mainly when funny metaphors are used which have essentially ambiguous interpretations.

Dee Dickinson et al. coincide with Dr. Gardner, who has created the Theory of Multiple Intelligence in the Classroom, supporting the idea of encouraging children to explore and exercise all of their intelligence. Among the eight different ways of intelligence, cited in his work, learning by playing is involved in the interpersonal intelligence in two aspects: in collaborative games and dramatic activities or role-playing; in an inner world through imaginative activities and games, among others [6].

Sean Brophy and Demetra Evangelou [7] argue that children's play naturally employs skills of observation and experimentation that lead to the development of intuitive models for how things work. They observed that children in their informal play are able to develop cognitive skills such as creativity for solving problems, sensitivity to other's perspectives, generating new knowledge and willingness to preserve toward a goal. Derived from an analysis of a series of video tapes, they concluded that children are interested in the process as well as in the product if they are actively engaged in its construction.

In [8], Maria Roussou explored interactivity virtual reality environments and their effects on leisure and learning. She made a critical review of examples of immersive virtual reality worlds created for children, with particular attention given to the role and nature of interactivity.

The previous works are related with learning through play in children context. However, as mentioned before, the use of analogies and metaphors could entail learning through play, such as has been the case of the work presented in this paper. Hence,

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some important definitions concerning analogy and metaphors, along with relevant works in this field are revised in the following paragraphs.

James Lawley [9] retook a definition of metaphors from *Metaphors We Live By,* written by the linguist George Lakoff and the philosopher Mark Johnson saying that: *The essence of metaphor is the understanding and experiencing one kind of thing in terms of another.* An important remark was made by Lawley by considering that a metaphor does not need to be limited to verbal expressions, but it can include *any* expression or thing that is symbolic for a person, such as nonverbal behavior, self-produced art, and an item in the environment or an imaginative representation. In other words, whatever a person says, sees, hears, feels or does, as well as what they imagine, can be used to produce, comprehend and reason through metaphor.

Another work by Garner R. [10] highlights aspects of playing by affirming that better comprehension, increased retention of material, and a more comfortable learning environment have all been attributed to the effective use of humor, analogies and metaphors. Meanwhile, Glenn [11] reported that the use of metaphors and other strategies can increase retention by as much as 40%, considering that humor and the use of metaphors in learning are linked.

The use of analogies and metaphor for teaching the qualitative research process on a Master's degree program in health and educational practices is treated in [12]. While analogies and metaphors can help students make creative and imaginative links between existing conceptual frameworks and those associated with new knowledge, thereby facilitating its assimilation, the use of analogies and metaphors remains a research area in nursing and educational practice. The use of metaphors and analogies can also facilitate the injection of humor to a subject students frequently find 'dry' and intimidating.

Reinders [13] presented an overview of the use of analogies and metaphors in learning science. The role of analogies in the learning process was analyzed from a constructivist perspective. The author considered that analogies may be valuable tools in conceptual change learning if their 'metaphorical' aspects were regarded. Thus, analogies and metaphors were viewed as close relatives.

The importance of developing explanations for scientific phenomena on their own when learner's background knowledge is incomplete or poorly organized was treated in the Wong's work [14]. Wong pointed-out that self-generated analogies, analogies produced by the learners themselves, are a tool by which individuals can generate, evaluate, and modify their own explanations.

Thus, under the optics exposed above, playing theater personages associated with situations of theater play can be considered as metaphoric and analogical aspects that could help in the learning process.

We propose a non-traditional learning method to reinforce knowledge previously learned by exploiting creative teamwork activities through playing roles of personages of theater plays. The learners create the play by writing the scripts, designing the wardrobes and mounting the stage.

The play should rely on funny dialogues, wardrobes and situations involved in the play, as conditions to be respected in its performance. Students should use or create analogies and metaphors capable of matching technical underlying concepts and their relationships by exploiting their creative capabilities during the activity of writing the script. Thus, learning through play is accomplished in several phases: during the task of creating the play by looking for funny situations where the metaphors and analogies should match with technical concepts; while students are designing the wardrobe and the stage; and when the performance of the play.

The objective of this work is to provide students with creative, fun and challenging learning frameworks aiming to improve the reinforcement and understanding of concepts related with topics previously learned and by encouraging the collaborative work.

The development of skills for facilitating the learning process is an expected result. Such skills are associated with creativity aspects, analysis, synthesis, abstraction, analogies and metaphors, and teamwork capacities, among others.

This method has been successfully applied since 2006 through the course of Integrated Manufacturing Systems (IMS) dealing with topics such as: Petri Nets, Group Technology, Industrial Robotics, Concurrent Engineering, Lean Manufacturing and Agile Manufacturing, among the most important. Topics belonging to IMS are particularly attractive, challenging and motivating for students because their applicability to real world problems.

This work is composed of the following sections: in section 1, the introduction exposes the context of this work; relevant related works dealing with the method of learning through play by emphasizing the use of analogies and metaphors as strategy for improving retention and understanding of concepts; and the main objective from the point of view of a learning method; section 2 presents the methodology that is used in the implementation of this method in real courses belonging to the undergraduate engineering program in our institution; in section 3 is exposed the assessment of the method and a discussion relying on the results before and

after the application of the method; finally, section 4 deals with the conclusions of this work.

2. Methodology

The following methodology has been implemented to apply the method presented in this work:

(1) The topics of the course to be reinforced have been previously given by the teacher in a traditional way.
(2) The teacher does not take part in the written of the script of the play neither in the design of clothes nor in the construction of the stage. He knows about the play until the official performance takes place.
(3) Two or three groups of theater are formed in order to establish a kind of competition. Thus, the performance of the actors is evaluated.
(4) The following conditions, related with the contents of the play, should be satisfied: (a) the script of the play should be original or adapted from other plays; (b) the dialogues, situations and clothes should be funny. So, the creative ingredient is obligatory exploited; the stage and clothes should be designed by themselves (creative aspects and teamwork are important); (c) the most relevant topics of the course, and their relationship, should be involved 'as personages' of the play. So, the application of concepts of the course should be part of the dialogues of the play.
(5) The play and the group are evaluated based on the originality and funny of the play and the correct match of analogies and metaphors with concepts of the topics being reinforced;
(6) A feedback by the teacher, invited public and students themselves is carried-out as final conclusion. The feedback mainly concerns aspects of the play and the application of analogies and metaphors to the concepts being reinforced.
(7) A before and after test, related with the concepts to be reinforced, is applied. The after-test is made to evaluate whether the retention and understanding of concepts have been improved.
(8) A survey is applied to know the opinion of students about the performance of the method, based on questions related with: its capacities for the reinforcement of knowledge and concepts previously learned; whether the method encourage and motivate students; how fun the method is; the degree of challenge by using this method.

In order to illustrate what a metaphor is, the following paragraphs expose two examples of metaphors used by two different groups.

2.1 Metaphor 1

A class of Integrated Manufacturing Systems is usually composed of an average of 16 to 28 students, so, at least two 'troupes de theatre' could participate in the method. The students are between 20 and 23 years old.

In the next paragraphs, some situations of two plays are reproduced to exemplify how analogies or metaphors are applied to match technical concepts with situations belonging to the play.

Name of the play: an adaptation of 'l'Avare' de Molière. The name of personages has been changed to be well adapted.

The concept to be reinforced: overgeneralization belonging to the Group Technology (GT) topic.

Group Technology deals essentially with the classification of parts in manufacturing systems. Thus, classes of objects are built by objects sharing similar characteristics. A classification should have always a well defined purpose. That is, a given classification of the same set of objects could be different to other classification using the same set of objects because they do not share the same purpose.

The overgeneralization damages the classification of objects because the risk of classifying objects that not share specific and relevant characteristics. In opposite, the over-specification damages also a classification because very specific characteristic are usually not relevant for the classification purpose.

The metaphor:
'(Beba)—It's not true! Men's from everywhere say the same things, their words are the same¡ They belong to the same class of rogues and despicable persons (crying and trembling), but my heart belongs to you'.

Based on this dialogue, men's (objects) from everywhere belong to the same class (rogues and despicable), which means that an over-generalization had been built.

2.2 Metaphor 2

Another example of the use of metaphors to explain a concept in Petri Nets is shown below. A Petri net is essentially a bipartite graph composed of two nodes, one representing a place and another one representing a transition. Petri nets are frequently used to model manufacturing processes. For instance, the pick and place task executed by a robot could be representing by a Petri net. In this case, the node-place represents an object positioned at the coordinates (x, y). The object should be picked and placed at other coordinates. The node-transition represents in this case the activity of picking and placing the object at its final destination. Another element of Petri nets is the token, which in this case repre-

sents the resources available to accomplish the task (pick and place an object). For this example, the token represents the object to be picked and placed. In such way that the token becomes the element that serves as condition to activate the transition, otherwise the transition cannot take place.

Name of the play: The murder of Dr. Flowers.

This play deals with the drama of Dr. Flowers' murder. He was assassinated after a party. There are five suspects. The metaphor uses the shot of the gun used to kill Dr. Flowers to illustrate the concept of token and transition.

Concept: token and transition of Petri Nets. A token is needed to fire a transition that transforms one state into another.

The metaphor:
At the beginning of the case, there are seven possible murders, the solution consist on the identification of characteristics of the suspects and the analysis of answers that they gave to the detective. The first token on a Petri Net for this case, is located at the place where the suspects spend time while Mr. Flores was killed. The Second Token verifies if the information expressed by the suspect is true or false. At the end, the Petri Net eliminates those who are innocent and keep going with the real murder.

3. Assessment and discussion

This method has been successfully applied since 2006, two semesters per year, in the course of Integrated Manufacturing Systems (IMS) of the Undergraduate Engineering Programs involving topics such as: Petri Nets, Group Technology, Industrial Robotics, Concurrent Engineering, Lean Manufacturing and Agile Manufacturing, among others. It is important to point out that the fact of requesting for an original play invented by students themselves, their creative side is exploited considerably. In addition, playing through funny metaphors and analogies and teamwork activities help to motivate and encourage the development of skills for learning such as, creativity, abstraction, make structures that relate concepts and reasoning by creating analogies and metaphors, among the most important.

The results showed that learning by playing within a play of theatre, created by themselves, the students apply the concepts by associating them to situations belonging to their personages or given them other meaning using metaphors, they reinforce the understanding of the concepts more firmly and arrive to build relationship between them for an integral understanding. Another important aspect is related with the motivation of students for learning in this way.

3.1 Assessment

The method has been assessed based on two tests applied before and after application of the method. The topic chosen to illustrate, in this work, the way of assessing the method is Group Technology (GT), because the potential application of concepts around this topic in the real world. The techniques used for classification in GT are quite similar to those used in Object Oriented Programming.

In order to evaluate the knowledge of concepts belonging to GP, two categories of concepts are considered: basic or underlying concepts and relations of concepts linked by pairs. The related concepts provide a more abstract meaning of the concepts.

Given that our interest is to measure the retention of concepts and explain the meaning of them, the questions applied in the exams are the following:

(1) To list and explain the meaning of underlying concepts related with Group Technology;
(2) To list and explain the most relevant pairs of concepts.

For the lack of space we do not specify qualitatively the concepts, instead we show quantitatively the results for eight semesters (since 2006 to 2009), where each class was composed of an average of 21-28 students. The total of evaluated students was 196.

The main basic concepts of GT are (18): Classification, Coding, Objects, Attributes, Classes, Subclasses, Subsubclasses, Instance, Instantiation, Grouping, Generalization, Over-generalization, Specification, Over-specification, Inheritance, Characterization, Metaclass, Superclass.

The most relevant pairs of concepts are (8):

- Objects-*grouping*-Class (which can be read as follows: classes are formed by grouping similar objects. The concepts to be linked are Objects and Classes);
- Class-*specification*-Subclass (it can be read as follows: a subclass is a specification of a class. The concepts to be linked are Class and Subclass);
- Subclass-*generalization*-Class (a class is a generalization of a subclass);
- Class-*overgeneralization*-Superclass;
- Attributes-*characterization*-Object;
- Subclass-*overspecification*-Subsubsubclass;
- Subclass-*instantiation*-Instance;
- Class-*Inheritance*-subclass.

The *italic* characters linking two pair of concepts listed above represent an action to be executed to transform one concept into another as explained between parentheses for some of them.

3.2 Analysis and discussion

Table 1 and its corresponding Fig. 1 below, show the results of questions oriented to reveal the number of retained underlying concepts of the Group Technology topic, which was learned during a traditional course of Integrated Manufacturing Systems. Two weeks after the topic was learned, the instructor asked students for listing the number of underlying concepts that they had retained. Table 1 and Fig. 1 show the behavior during 8 semesters, since 2006 to 2009 for a total of 196 students.

Three segments were considered, which are related with the number of underlying concepts that the students had retained: 1 to 5; 6 to 12; 13 to 18. The segments were built based on the relevance of underlying concepts. For instance, the segment 1 to 5 contains the most relevant concepts of the topic, which are the following: Objects, Attributes, Classes, Over-Generalization and Over-Specification. Curiously, they retained much more the concepts of over-generalization and over-specification that the concepts that they are derived from, that is, generalization and/or specification. The reason could be that during the course a warning is recurrent: over-generalization and over-specification damage the classification. Generalization and specification concepts are incorporated to the segment 6 to 13. The other concepts incorporated to this segment are sub-class and sub-sub-class.

Derived from the results shown in Table 1 and Fig. 1, we can see that an average of 46.48 % (91 students out of 196) retained between 1 to 5 concepts; 29.61% (58 out of 196) retained between 6 to 12 concepts; and 23.83% (almost 47 students out of

Table 1. The retention of concepts two weeks after the topic was learned in a traditional way

Year/Semester	1–5 Concepts	6–12 Concepts	13–18 Concepts	Number of Students/ Semester
2006-1	12 (48%)	8 (32%)	5 (20%)	25
2006-2	11 (45.8%)	8 (33.3%)	5 (20.8%)	24
2007-1	11 (40.7%)	9 (33.3%)	7 (25.9%)	27
2007-2	13 (46.4%)	7 (25.0%)	8 (28.6%)	28
2008-1	9 (40.9%)	7 (31.8%)	6 (27.3%)	22
2008-2	11 (45.8)	6 (25.0%)	7 (29.2)	24
2009-1	13 (52.0%)	7 (28.0%)	5 (20.0%)	25
2009-2	11 (52.4%)	6 (28.6%)	4 (19.0%)	21
	Average (46.4%)	Average (29.6%)	Average (24.0%)	Total 196

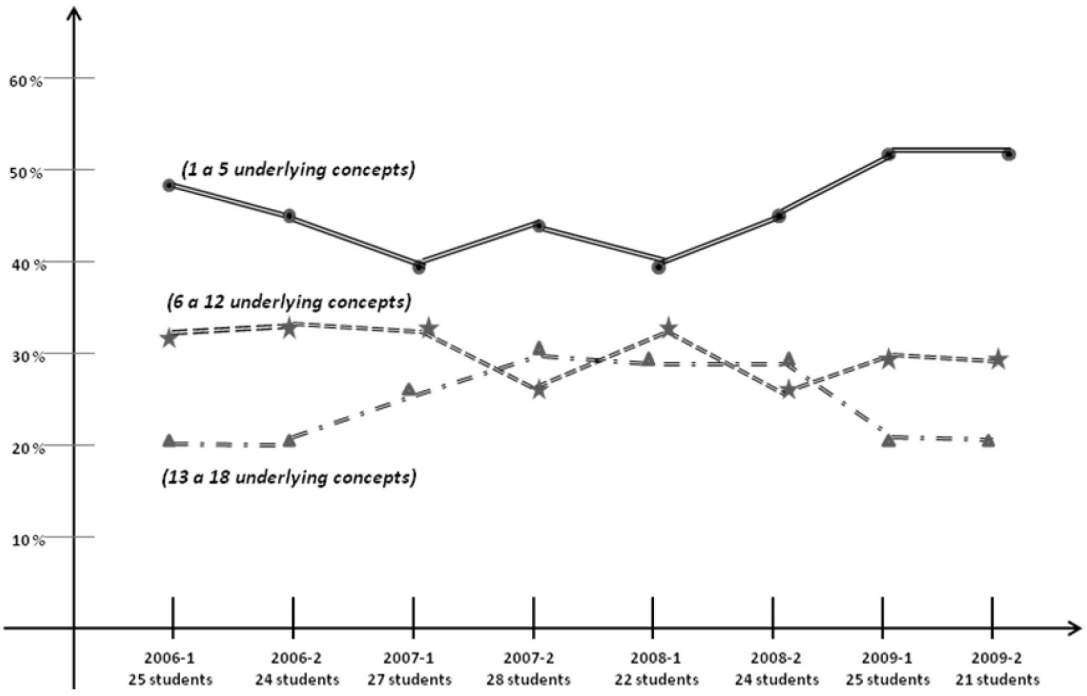

Fig. 1. The performance of concepts retention is low before the application of the method. Approximately 20 % was capable of retaining 13 to 18 underlying concepts.

Table 2. The performance of retention of underlying concepts was inverted considerably after the application of the method

Year/Semester	1–5 Concepts	6-12 Concepts	13–18 Concepts	Number of Students/ Semester
2006-1	3 (12.0%)	4 (16.0%)	18 (72%)	25
2006-2	3 (12.5%)	5 (20.8%)	16 (66.7%)	24
2007-1	4 (14.8%)	5 (18.5%)	18 (66.7%)	27
2007-2	4 (14.3%)	5 (17.9%)	19 (27.9%)	28
2008-1	2 (9.1%)	4 (18.2%)	16 (72.7%)	22
2008-2	3 (12.5)	4 (16.7%)	17 (70.8)	24
2009-1	4 (16.0%)	4 (16.0%)	17 (68.0%)	25
2009-2	2 (9.5%)	4 (19.0%)	15 (71.4%)	21
	Average (12.8%)	Average (17.9%)	Average (69.4%)	Total 196

196) retained between 13 to 18. This result in a poor performance of retention because just 1 out of 4 students were capable of retaining between 13 to 18 concepts, and most of the students, almost 50%, retained just 1 to 5 of a total of 18 underlying concepts.

Table 2 and Fig. 2 show the results after the application of the method presented in this work. As we can see, the behavior was inverted, because in this case almost 7 out of 10 students were capable of retaining 13–18 underlying concepts, meanwhile 1 out of 10 students retained between 1 to 5 underlying concepts.

The concepts linked by pairs usually more retained are: objects-*grouping*-classes and class-*over-generalization*-superclass. That is the reason why we have considered these two in the first segment 1 to 2. Other pairs such as: class-*specification*-subclass and subclass-*generalization*-class are incorporated in the second segment 3 to 5. This segmentation has been built also based on the experience.

For the lack of space we do not show the performance related with the description of pairs of concepts. However, its behavior is quite similar to the behavior derived from the description of underlying concepts, that is, the number of students retaining more pairs of concepts increased after the experience of the theater.

Another important aspect to be highlighted is the time to be spent by using the theater method com-

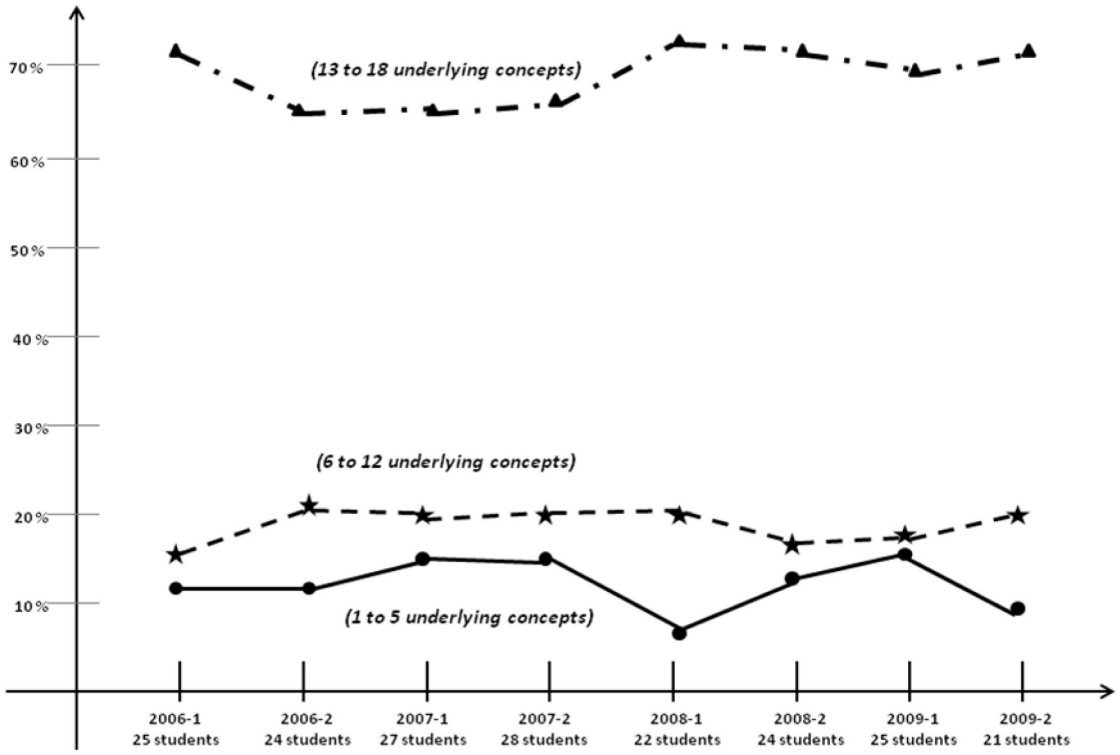

Fig. 2. The performance of concepts retention was inverted, as shown in this figure, after the application of the method. An average of 70 % of students was capable of retaining 13 to 18 underlying concepts and a low percentage, about 10%, retained 1 to 5 underlying concepts.

pared with the spent time using the traditional way of learning. There are 32 sessions of 1.5 hrs each, for the total duration of the course of IMS. In a traditional course, the topic of Group Technology takes three sessions, plus the exam that is prepared in one week, which is applied two weeks after the end of the third session. Thus, there are a total of two weeks and half to accomplish the requirements of this topic, including the exam. Using the method of playing theatre, there are three sessions plus two weeks to prepare the piece of theatre, including the performance. Thus, it is spent also a total of two weeks and half. In conclusion, the two methods spent similar time. However, as we have exposed in this article, the performance related with the retention of concepts is larger better using the method based on playing pieces of theater. In addition, the students are more motivated and they develop their creativity skills and the group work.

3.3 A survey

A survey was applied to know the opinion of students based on four questions. Table 3 shows the result of the four questions. The sample in this case was of 40 students that took the course in different semesters.

Question 4 is the most important question, which concerns the reinforcement of concepts. We consider that 100% of students agree about the valuable contribution to this aspect, because 'Too much' (62.2%) and 'Much' (36.7) are quite closed and their sum totalized practically 100%. Based on the answers to the questions specified above, the method had, in general, positive opinions.

This method has a serious risk if the instructor does not have enough experience to control the group, because some students do not trust in alternative methods. So, based on the experience of about 5 years, sometimes the behavior of the class does not allow to put in practice this method, for several reasons: they believe that it is not a formal method for engineering programs usually supported by mathematics expressions; even though the method attempts to integrate students in team working, sometimes an important number of students in a class do not want to be integrated; some students consider that these kinds of methods belongs to programs related with human sciences (communication); and others consider that these methods are much more ad-hoc for children context. If the instructor has enough capacities to control these disadvantages the method can be applied and it will be surely a success, otherwise the risk of fail is high.

3.4 Testimonials

We expose two testimonials of students that took the first course using this method:

(1) *'This learning method was a successful one, because the teamwork activities during the creation of the play and during the performance of it. It provides much more fun moments compare with traditional methods. The concepts became clearer with more impact for the class. The fact of involving the student in the learning process is more efficient and less stressing'*. Ana M. Zaldivar V. September, 2006

(2) *'One thing is really clear for me; I will never forget the concepts and the way that I learned them. The method based on analogies and metaphors involved in a play that we created and performed gave me not only knowledge, but this learning process requested me the use of my imagination, creativeness, team work, and the most important: It makes me think in which situations the knowledge of Integrated Manufacturing Systems could be used and its impact. The students laugh and paid continuous attention to the play and the analogies and metaphors. It has passed more than 8 months from that activity and I perfectly remember each of the moments of that learning process'*. Francisco Salinas. September, 2006. Francisco Salinas practices this technique in his professional life, thanks to his interest and contribution to this method he is one of the coauthors of this article.

3.5 Some photographs of the play

Figure 3 shows important moments of one of the

Table 3. A survey to know the opinion of students about the use of the method

Questions:					
(1) Does the method encourage and motivate students?	Very Much 50%	Much 42.9%	More or Less 7.1%	Little	Nothing
(2) Was it a fun learning method?	Very Fun 71.4%	Fun 28.5%	+/− Fun	Little Fun	Non Fun
(3) Was it a challenging learning method?	Very Chall. 14.2%	Challenging 78.5%	+/− Chall 7.1%	Little Chall	Non Chall.
(4) Did you reinforce the knowledge and concepts previously learned?	Too much 62.2%	Much 35.7%	More or less	Little	Nothing

PHOTOS

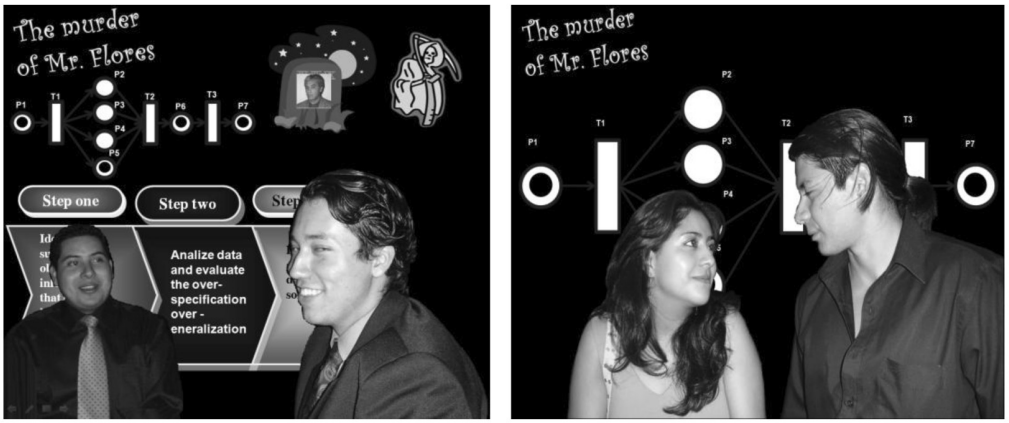

Fig. 3. Two situations of Mr. Flowers' case: explanation of Petri Nets.

theater play 'The murder of Dr. Flowers' and some participants of the play.

4. Conclusions

Learning through play is possible in higher education levels of engineering programs if learning methods such as the one presented in this work is used. In order to be a successful method, some important ingredients should be taken into account related with teamwork activities, challenging to exploit creativity capacities and provoking funny situations and dialogues.

The fact of using analogies and metaphors brings about doses of creativity and the effort of matching the metaphors or analogies, generated through invented situations, and technical concepts requires the exercise of analysis and abstraction that result in the improvement of retention and understanding of the concepts being reinforced.

Through the use of this method, the learning through play aspect occurs at several moments of the learning process: during the task of creating the play by looking for adequate analogies and metaphors; during the time of designing the wardrobe and the stage; and during the performance of the play.

Based on the survey applied after the course, we can deduce that it is a successful method of learning, even in the context of engineering higher education. However, the instructor should monitor the attitudes of students to be sure that they are available for this kind of experience. Otherwise it could become the contrary of the desired results. In [15], Paul Hager pointed-out that 'whilst metaphors aid our understanding of things by suggesting novel insights, they can also mislead if too much is read into the supposed likenesses'.

References

1. P. K. Smith and A. Pellegrini, Learning Through Play, Encyclopedia on Early Childhood Development, September 2008.
2. P. K. Smith, M. Dalgleish and G. Herzmark, A comparison of the effects of fantasy play tutoring and skills tutoring in nursery classes, *International Journal of Behavioural Development*, **4**(4), 1981, pp. 421–441.
3. Oregon State University/ExtensionService, Learning Through Play and Fantasy, September 2006.
4. J. Gee, What would a state of the art instructional video game look like?. *Innovate*, **1**(6), 2005, http://www.innovateonline.info/index.php?view=article&id=80. Accessed 13 February, 2010.
5. D. Oblinger, *Simulations, Games, and Learning*, EDUCAUSE Learning Initiative, May 2006.
6. L. Campbell, B. Campbell and D. Dickinson, *Teaching and Learning Through the Multiple Intelligences,* Allyn & Bacon, 1999.
7. S. Brophy and D. Evangelou, Precursors to Engineering Thinking (PET) Project: Intentional Designs with Experimental Artifacts (IDEA), *American Society for Engineering Education*, 2007.
8. M. Roussou, Learning by Doing and Learning Through Play: An Exploration of Interactivity in Virtual Environments for Children, *ACM Computers in Entertainment*, **2**(1), January 2004, Article 1.
9. J. Lawley and P. Tompkins, Learning Metaphors. First published in the SEAL Journal, December 2000.
10. G. Randy, Humor, Analogy and Metaphor: HAM it up Teaching. Radical Pedagogy. ISSN: pp. 1524–6345, 2005.
11. R. Glenn, Brain research: Practical Applications for the classroom, *Teaching for Excellence*, **21**(6), 2000, pp. 1–2.
12. S. H. Cook and M. Frances Gordon, Teaching Qualitative Research: A Metaphorical Approach, *Journal of Advanced Nursing*, **47**(6), pp. 649–655. Blackwell Publishing Ltd. August 2004.
13. Reinders Duit, On the Role of Analogies and Metaphors in Learning Science, *Science education*, **75**(6), pp. 649–672. Wiley Periodicals Inc. August 2006.
14. E. David Wong, Self-generated analogies as a tool for constructing and evaluating explanations of scientific phenomena, *Journal of Research in Science Teaching*, **30**(4), pp. 367–380. Wiley Periodicals, Inc. Aug 2006.
15. P. Hager. Learning and Metaphors. Medical Teacher, Volume http://www.informaworld.com/smpp/title~db=all~content=t713438241~tab=issueslist~branches=30—v3030, (7) 2008, pages pp. 679–686.

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Francisco Salinas is a senior consultant and instructor in business intelligence and automation of processes for several enterprises and educational organisms, where he has applied the methodology presented in this work to about 4000 persons. Francisco Salinas holds a Bachelor's Degree in Industrial Engineering from the Tecnológico de Monterrey, Campus Cuernavaca. He is interested in evolving and improving the operational culture of organizations and institutions through training mechanisms.