International Journal of Engineering Education Vol. 27, No. 3, pp. 535–549, 2011
Printed in Great Britain
0949-149X/91 $3.00+0.00

Innovative Experimental Approach of Learning-Through-Play Theory in Electrical Engineering*

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In this paper we introduce an approach of play-based learning within electrical engineering. The proposed methodology tries to develop a play-based experience by two stages: firstly, the learning by doing theory will teach the 'rules of the game' and then, it is completed with a final practice that implements the rhetoric of the learning-through-play theory. Both techniques have resulted in positive learning outcomes by enhancing the student role in the learning process through increasing the motivation.

An experimental play-based Wireless Sensor Network (WSN) platform is introduced as an aid in teaching location techniques based on RSSI (Received Signal Strength Indicator) in the frame of a radiolocation course at graduate level. The platform is implemented using low-cost commercial modules and one easy-to-use software program.

We deepen in the layout challenges facing instructors in the frame of a play-based learning experience. So, we outline critical points as the teacher's role, the time constraint and the trade-off between actual advantages and efficiency.

We propose also one method to correctly evaluate the cognitive and affective dimensions of the play-based settings by the development of a smart learning route chart that represents a study guidance indicating the flow expected for the objectives and its evaluation.

Keywords: learning through play; learning by doing

1. Introduction

Higher education has experienced deep changes in the last decade powered by the demands of different agents and factors. These changes have been materialized in the development of new learning and teaching methods that try to improve the way of interacting with students. Regardless the selected methodological approaches, the development of innovative material as well as new will be a short-term demand in the new study plans that incorporate the European Higher Education Area (EHEA) requirements. Instructors should deepen in the many options offered in the quest of a winning teaching/learning formula.

A usual objective of the different methodologies is to attract and maintain student interest during the class without losing the cognitive dimension of the experience. The learning-through-play theory appears as an acceptable mode of reaching this objective. It is a fashionable and amazing learning methodology but it represents also a challenge for educators that try to implement them in their classrooms, especially in electrical engineering. Traditional methodologies are more extended in this field than innovative means, and sometimes the play-theory find reticence among educators that think in these play-based methodologies only considering the 'fun' factor.

In the design of a play-based teaching experience the instructors have to balance opportunities, challenges and risks. The first of them is the teacher's role during the game-based learning. The definition of the play-based experiences leads the teacher to a secondary role during the realization of the game. But this passive role can drive the students to failure and to unsatisfactory feeling. The same can happen in the instructor that leads to leave seeking innovative means.

We propose in this paper the design and implementation of play-based experiences through two successive stages. In an early first stage, the 'rules of the game' must be explained to the students. During this stage, the students would acquire a set of theoretical and practical knowledge and skills targeted for covering one or more topics of the course involved in the learning experience. For this stage, complementary teaching methodologies can be applied, as the learning-by-doing theory.

In a second stage a final practice is developed according to the rhetoric of the play theory. Along the two stages the teacher's role changes from a classical transmitter of knowledge to orchestrator of the experience and collaborator to support and to facilitate reflection.

A smart learning route chart has been elaborated containing the successive steps to follow during the play-based practice as well as the

* Accepted 15 October 2010.

learning objectives. This guide is given to the students so they know a priori the milestones expected to achieve. The evaluation methodology is also indicated.

The combination of this double-stage strategy, the adequate teacher's role and the smart learning route chart improve the benefits of the through play experience. Among other benefits we can mention firstly, that it helps to summarize the concepts and skills objective for this block of the course content; secondly, it allows the student a general scope of the technique presented that can help to clarify some remaining doubts. In itself this challenge constitutes an auto-evaluation of the previously learned concepts.

The play-based methodology has been applied in computational and engineering teaching field showing a large level of satisfaction, and becoming also mostly effective at the cognitive level. Related experimental systems have been previously developed regarding WSNs [1–2], and they can be also found in the field of electromagnetism teaching, computer science and robotics [2–8]. In [2,6] we can read the importance of the instrumentation in the radio courses curriculum and how the RF instruments and experimentation can help to emphasize signal and system theory concepts to students within the line of active learning pedagogy.

Active learning experiences require the acquisition or development of specific material. In [7–8] cost-effective solutions are implemented to design educational modules used in wireless communication courses showing a good performance. In our case, a modified commercial kit has been used to deploy the WSN. The system was completed by programs developed in MATLAB software. This allows planning different experiments focused on the main concepts related to location estimation based on RSSI technique, as well as routing in a Zigbee network.

Another not less important aspect to consider along the development of this kind of learning methodology is the way of evaluating the acquisition of knowledge. It is essential to collect information in the cognitive and in the affective dimension. This information has to be analyzed to evaluate a classical trade-off: the satisfaction level and the effective cognitive learning.

In section 2 we introduce the theoretical background of the teaching experience. The developed teaching methodology is explained in section 3, including the implementation. Finally, in section 4, we present the evaluation method followed to infer the progress and success of the experience. In the last section, we offer the conclusions to this research work and indicate some ideas for future work.

2. Active learning in the classroom

Traditional lectures are the more extended teaching method that can be found in the colleges and universities. But in the last two decades this traditional methodology has suffered a clear evolution toward other forms of understanding the knowledge acquisition [10–11].

The present teaching process is based on the producer-consumer paradigm [11], with some who knows and provides the information (producer) and someone who does not know and listens. This process has an economical reason that tries to optimize the resources: more students per teacher, more students per laboratory . . . In this model where only economical criteria are considered, the lecture method is doubtless the more effective form to transmit the knowledge.

Among the deficiencies that can be found regarding traditional methodologies as lectures we can mention:

(1) Not learning-centered.
(2) Students not actively involved.
(3) Skill acquisition is not guaranteed.
(4) Negative effect on student's emotional involvement.
(5) Negative effect on student's motivation.
(6) Not fair evaluation methods.
(7) Discourage contact between students and faculty.

The more adequate learning is not that one where the contents to be acquired are presented in its final form, either that one introducing the concepts has to be discovered by the learner that becomes in an active role either than in the passive role provided by traditional focuses [12–14].

The learning is an active process where the information activity process implies that the learner must build and reorganize the knowledge into his/her own cognitive structure by means of different representation levels [12–14]. This means that the learning is produced when the information is transformed according the rules developed by the own experience. Hence it is stated the importance of the experiential learning.

Different 'cones of learning' can be found along the educational literature [15], and although some controversies exist about the numbers contained in the different representations, we reprint here two of them [16–17] in Fig. 1. The percentages represent the average 'retention rate' of information following teaching or activities by the method indicated. The main message that we can extract is the underlying idea of that an active experience provides cognition 'harder to forget' than other passive experiences.

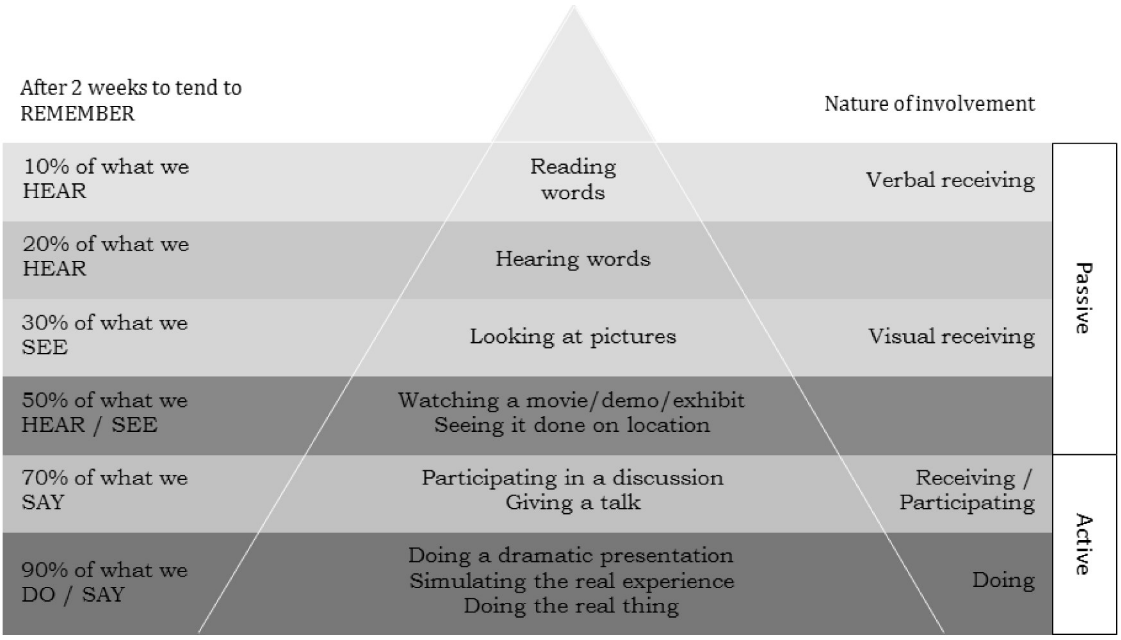


Fig. 1. Learning pyramid or cone of learning [16, 17].

The principles, created by [10], include the following key practices to improve teaching and learning:

(1) Encourage contact between students and faculty.
(2) Develop reciprocity and cooperation among students.
(3) Use active learning techniques.
(4) Provide prompt feedback.
(5) Emphasize time on task.
(6) Communicate high expectations.
(7) Respect diverse talents and ways of learning.

So, we can state that education has evolved from a teaching to a learning focus and the incorporation of active learning is the way for this transformation [18]. Active learning has demonstrated to be more effective than passive learning [14].

The development of material that incorporates active learning experiences is a challenge for the instructors that are not usually encouraged to face this step. Among other reasons, the EHEA process has determined the university and studies structures but not the training methodologies that should consider the use of active methodologies to improve the student learning process.

But due to the social demands and the requirements of industry, the instructors should face the challenge of considering the inclusion and selection of an active methodology in the class mainly in technical disciplines [19].

The development of material considering active learning methodologies is not free of risks. The short-term experiences are preferred always, and the methodology to implement depends on the goal, the student, the content, and the teacher.

In this section we analyze two main methodologies that try to incorporate active learning teaching: learning by doing and learning by play. We have selected them among other ones due to the suitability to our goals and contents.

2.1 Learning by doing

The learning based on the experience, experiential, factual, 'learning by doing' or 'hands-on learning' is generally framed in the active learning methodologies. This supposes to encourage people to discover by themselves the principles of operation of the systems, processes, etc. through the experimentation and the exploration [20].

By this way, learners would develop an understanding of the relationships between specific techniques and generic conceptions of technological processes, and between specific pieces of equipment and their functions [19] in an attempt to interconnect the specific with the general and the material with the abstract, i.e. to connect different kinds of meaning [19].

An experiential learning method is based on three assumptions [21–22]:

(1) Learning is more effective when people are personally involved in the learning experience.
(2) Knowledge has to be discovered by the individual to have significant meaning.
(3) Personal motivation to learning is highest if the own learning objectives can be freely set [23].

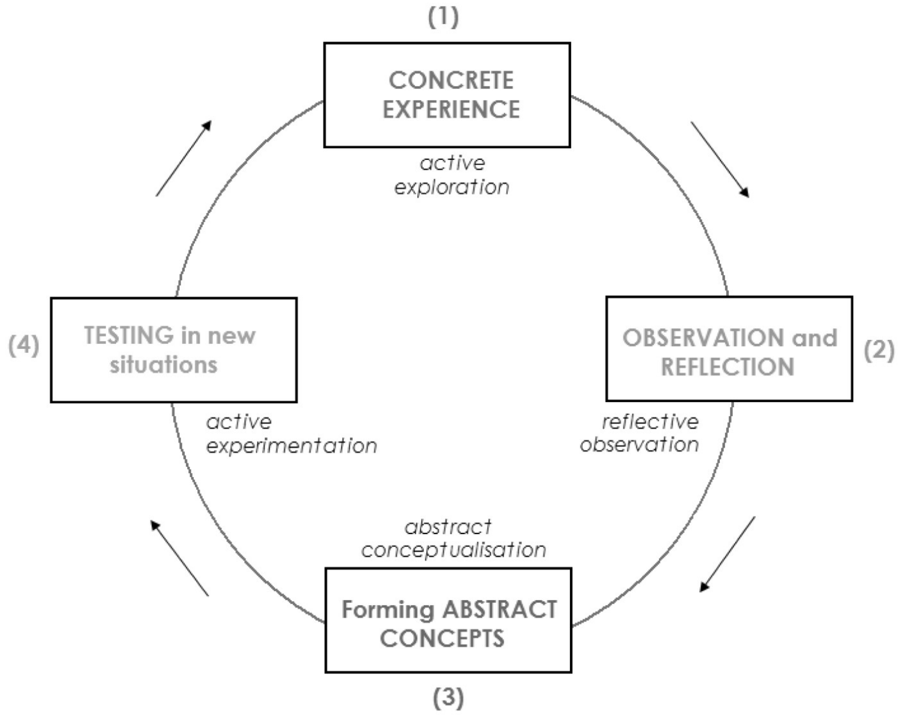


Fig. 2. Stages in learning by doing (experiential) method [21].

This kind of methodology promotes the construction of deep cognition and increases the comprehensive as well as the effectiveness and efficiency to put in practice the learned skills [21] according to a succession of stages as indicated in Fig. 2. This feature is largely interesting to give the students a practical view for their imminent professional future.

Learning by doing experiences can be faced by two main approaches:

(1) Field experiences: provides larger motivation but may suppose expensive investment in material.
(2) Simulations: usually known as software-based methodology, results in less investment and motivation [24].

2.2 Learning through play

As observed in [25], play is a powerful tool for learning that becomes fundamental for both adults and children development [26–28] allowing part of the evolving human experience once it provides a way in which we learn by offering the opportunity to practise and explore in a safe environment teaching essential skills. This methodology has been widely applied in computational and engineering teaching field [29–32] showing a large level of satisfaction, and becoming also largely effective at the cognitive level.

But this technique is not free of risks. The main weak point to take in mind is that students need to know *a priori* 'the rules of the game'. The background knowledge level plays an important role in the success of this kind of experiences. It is not possible to play a game if the rules are not well understood. If this happens, the loss of motivation produced on the students can be important resulting in a failure of the practice. This produces also discourage on the instructors. Students must learn the fundamental concepts and the necessary skills prior to apply them effectively in a game-based experience.

As the above case, the game-based or through play methodology can be implemented developing field practices or PC based simulations. The first ones involve a large implication of the teacher during the realization. The second kind entails a large time out of class to develop the proper platform.

There is the assumption in research literature that plays in form of computer games are a useful educational tool because of their effect on the students' motivation. Some works [25, 33] question about this statement and warn about the assumed motivational potential of their use in Higher Education. The study developed by [25] concludes that it cannot be established a relationship between the students' motivation to play for leisure and the motivation to do it for learning.

In [33] we find a deep analysis of the features that a game-based experience should present, and even this analysis is oriented to computer-based games, they result applicable to any play experience. The problem-based learning is presented as the pedagogical praxis to encompass the requirements of a successful game experience from the point of view of cognitive apprenticeship. This point of view is shared by [25] who remarks that games/plays features should be active, problem-based and collaborative in order to become effective learning environments/experiences, concluding that games must exhibits the characteristics of constructivist learning [34].

We agree the statement of that the design of play/game-based experience should be focused on learning and outcomes, so enabling the students' engagement for learning. The affective dimension must be monitored so we can evaluate and correct the motivation and satisfaction for learning in an alternative way represented by the play.

The selection of teacher's role during the play becomes an important design criterion. Three roles can be assumed, and in them we can identify three main features: the student-student interaction or group collaboration/dynamics, teacher-student interaction, and reflection facilitating to produce or correct cognitive learning and to allow surfacing tacit knowledge through play. These roles are:

(1) Teacher as an external instructor or orchestrator: explains the play and keeps invisible during the play, waiting only for the final results. The teacher-student interaction is inexistent until the end of the game, or even forever if a posterior teacher-student interaction is not planned. The group collaborative strength should be large, but the group dynamics can disappear if the responsibility is not equally assumed by the group members.
(2) Teacher as a collaborator or team-member: it provides reference model and strengthens the teacher-student interaction. It provides an important feedback about the learning goals accomplishment.
(3) Teacher as a provocateur: as an external watcher, it provides reflection to problems identified during the game. Here the teacher-student interaction reaches a medium level. However, this role facilitates the group dynamics due to the 'watcher presence' factor.

The above mentioned teacher's role represent different approaches in tracking the activity of the students and controlling the degree of correctness in learning the objective concepts [35–36]. The role of team-member provides the most suitable approach to measure the success in accomplishment of the learning goals. In the extreme side, we find the orchestrator role.

Another important design criterion regards the time constraints. The use of the through-play/games method can do necessary an additional time (preparation, maintenance, realization) and the evolution in teaching concepts can seem to result slower. As we explain in section 4.1, the time is another variable in the equation to balance risks and benefits: a short time would avoid correct conceptualization, whilst long-time produces loss of motivation.

3. Teaching methodology

The experience described in this paper tries to approach the teaching of one primary location technique that can be widely found in radio wireless applications. It is inscribed in the framework of the graduate-level course *'Radio determination'* offered in the last year in the Electrical and Computer Engineering degree at the University of Vigo, Spain.

This course is optional, so students decide to select it according to a criterion of the curriculum/profile that they desire to develop. Usually, students with specialization in radio select this course, but it is common also to find students from the networking or electronics branches who present a not intensive background in radio propagation.

Among the criteria that students hold to select an optional course, the attractiveness offered by the course and the grade of update showed are factors playing an important role.

The contents of the course include radionavigation and radiolocation systems used in aeronautics and aerospace, as landing aid systems (ILS, VOR), or navigation aid (GPS, Galileo, GLONASS), and radiogoniometry. The theoretical contents are given following traditional lecture classes, and lab practices have been designed according to a learning-by-doing methodology.

In the last years, the radio location techniques are spreading the field of use and they are commonly found in many dairy applications. Some of these radio locations methods have become very popular thanks to the emerging wireless communications in unlicensed bands, especially the Wireless Sensor Networks (WSN) case have awaken a large interest due to their attractive features and simplicity of implementation. The incorporation of Zigbee protocol offers additional value and facilities to these networks.

Along course 2008/09, the subject has incorporated the teaching of radio location techniques in the frame of WSN to complement the third block of the course contents, with theoretical classes and practical experiences. In the past, only a documentation work and a survey were required to evaluate this block due to the difficulties found to implement lab practices, mainly from the point of view of the resources.

But these techniques can be hardly understood if only theoretical explanations are provided, and even if software simulations are employed. On the other side, one objective of the active learning is to attract the attention of the students and keeping their motivation. A combination of learning-by-doing and learning-through play has considered the optimal solution to join both cognitive and motivation milestones.

In the following sections we present the resources that have been used and developed in this experience, as well as the details of the practical implementation.

3.1 Resources: the toys construction

Learning by doing experiences based in field experiences imply the use of material that sometimes is not covered by the general purpose instrumentation. The acquisition of specific educational material is large-cost and not usually affordable.

But many solutions exist in form of development kits available for the industry and perfectly valid for academic purposes. It has been our case, and we proceeded to acquire a Zigbee WSN commercial kit with the feature of estimating the power of the received signal. The core chip used by this kit incorporates the transceiver front-end as well as an 8051 core to program the user applications.

In order to implement a radio location system to estimate the position of a mobile user, three elements are mainly necessary, so we have developed specific hardware systems for each one of this elements:

(1) Reference units (RU) at known positions transmitting a predefined value of power. They act also as routing elements of the information transmitted from the mobile users.
(2) Mobile terminal units (TU) with unknown positions that estimate the power received from the RUs (Received Strength Signal Indicator, RSSI) and feedback this value to the master node (MN) using the network of RUs.
(3) Master node: in our case, this node is the responsible of estimating the TU position by triangulating the power received from it at the RUs. The triangulation implies the assumption of one radio mobile channel, one important concept of this experience besides the own triangulation technique. The MN is connected to a computer via RS-232.

In Fig. 3 we show the three elements above described, and it can be shown that they share the same chip board. A brassboard has been designed for the TUs, containing one led-push button, reset button and one inclinometer. Sensors can be easily incorporated for future use.

Additional software elements have been designed to complete the toys/material required for this experience. The robust closed-form software tools developed will facilitate to the students the development of the experience helping them to focus on the targeted concepts:

(1) Compiled C Code for RUs: it includes the functionalities of network routing and power message transmission.
(2) Compiled C Code for TUs: it includes the functionalities of network routing and power messages reception. Automatically selects the frequency channel of operation, and it recognizes the ID assigned to each node.
(3) Compiled C Code for MN: it includes the functionalities of network routing and the serial communications with the computer.
(4) Student program: implemented in Matlab, it receives the data needed for the triangulation according to the propagation model.

The code corresponding to RU, TU and MN has to be uploaded to the core chip via JTAG programming tool as indicated in Fig. 4. The set of software/hardware can be seen as the 'toys' needed for the play, in a similar way to other related experiences that use commercial kits, as LEGO or robots [9].

The student program has become fundamental for the development of the experience. It provides functionalities to dimension the network, to assign a role to a board chip (TU, RU, MN), to fit the propagation model and to perform correctly the triangulation. In Fig. 5 it is shown the main screen of this tool.

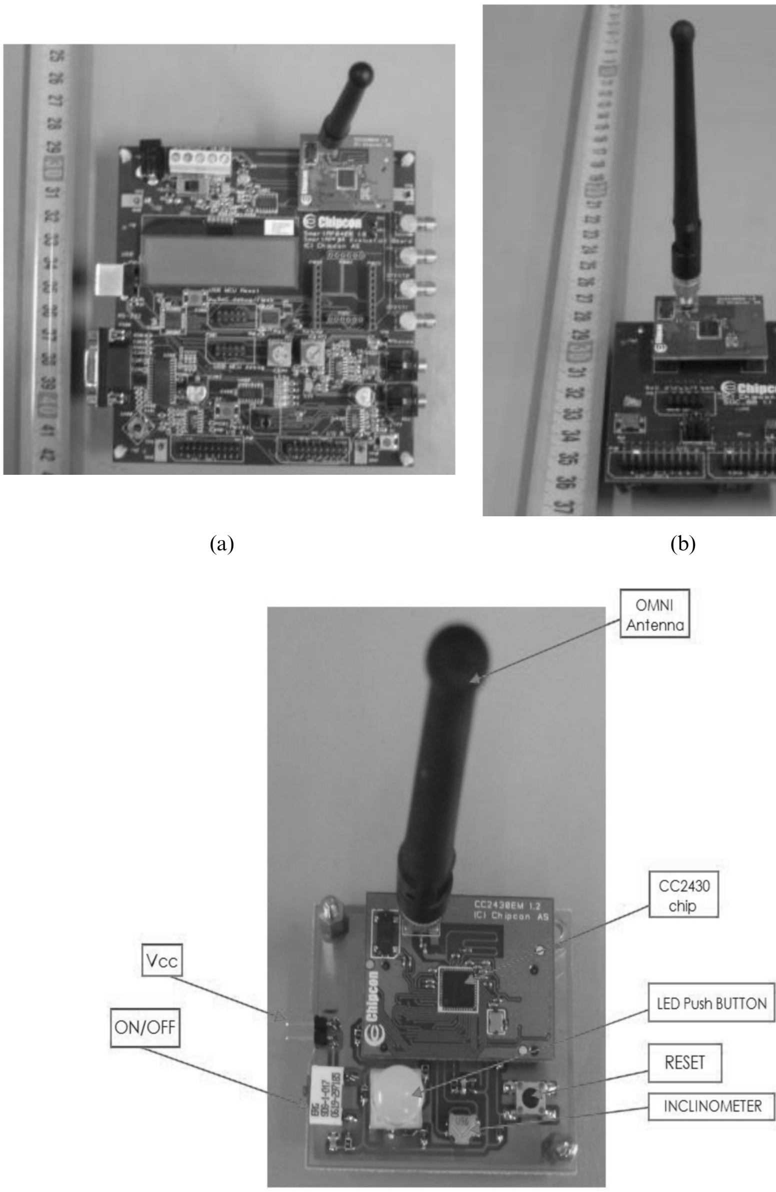
3.2 Implementation of the experience

As we have introduced, a double-stage methodology has been designed trying so to distinguish between a training period useful to show the play rules, and the challenge stage implemented as a *through-play* experience.

A learning-by-doing methodology has been estimated as an optimal solution to present the *modus operandis* of real time positioning systems based on the estimation of the received signal strength. Firstly, a set of four short practices introduce the different objective concepts. One session of two hours has been assigned to each practice. Students elaborate one four-page report after the completion of the each practice.

Following we briefly describe the main milestones of the initial four short practices:

(1) Dimension the network and assignation of one role to the chip boards. Some parameters of the



(a) (b) (c)

Fig. 3. (a) Master node (b) Reference node (c) Terminal user.

RUs and TUs as ID, and position (X, Y, Z) have to be predefined. In Fig. 6 the node setup menu is shown.

(2) Test of communication: the different elements are activated and the network deployed in an actual indoor scenario. Test messages are routed among the nodes. A mesh topology is followed.
(3) Fit the propagation model: one main parameter of the propagation model has to be set: *N*. It approximates the power decay curve for the signal transmitted from one RU and received by one TU. This propagation model is commonly used in indoor scenarios, and as is called log-distance model. The accuracy in the estimation of *N* is deeply related to more accurate position estimation. In Fig. 7–8 it can be observed the model fit menu.
(4) Triangulation: students have to implement the algorithm for position estimation based on the equilateral triangulation technique of received RSSIs. In Fig. 9 it can be observed an output example of this practice.

After this, the methodology is completed with one final practice that summarizes all the learned concepts and is valid to put in practice the skills learned and developed by the students. It is presented in form of through-play.

As an outcome of the initial practices, the stu-

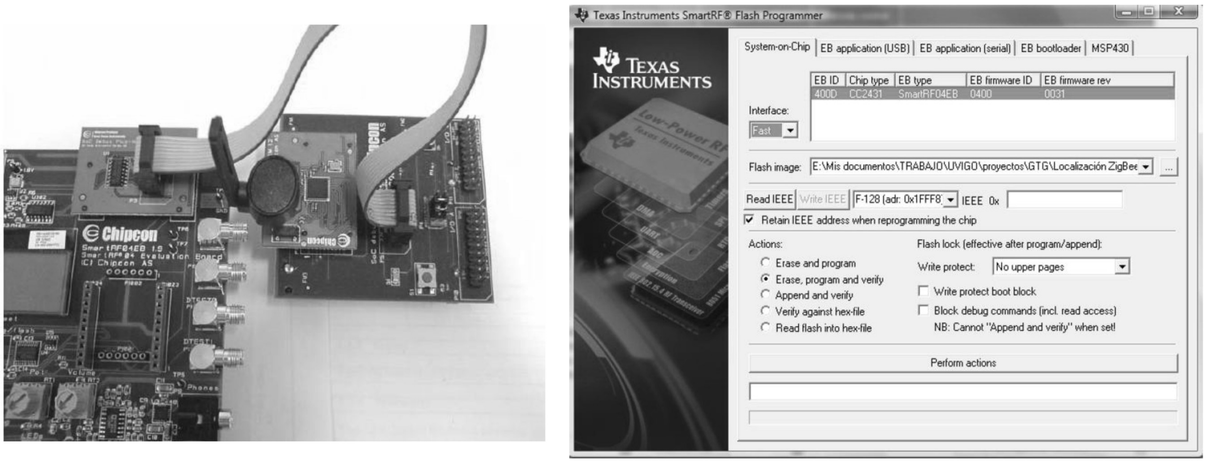


Fig. 4. Programming facilities.

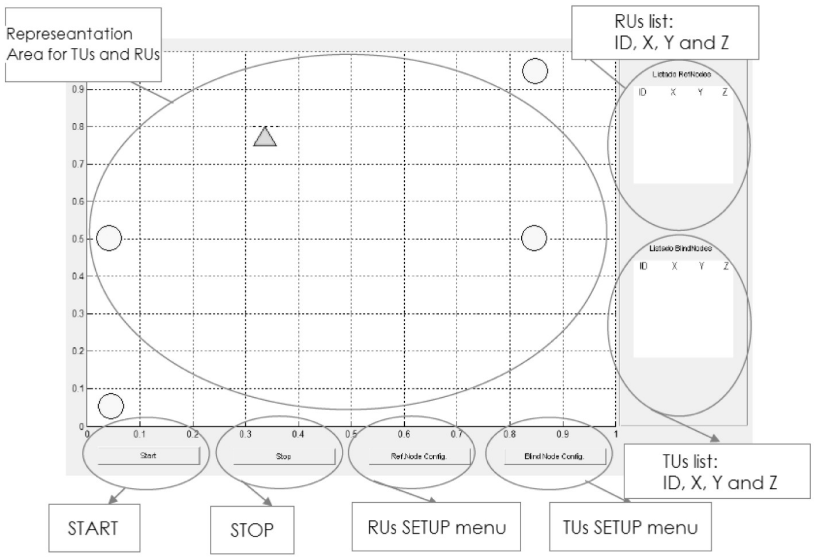


Fig. 5. MATLAB student's interface program.

dents are in position of estimating the location of any TU, as well as the ID of the available RUs, in the deployed network always that the learning process has been successfully completed. So, in the next step they have to determine under blind conditions, which RU nodes of the network are working, how many TUs are active and also they have to determine the TUs location.

If the software tools have been correctly fitted, and a comprehensive cognition has taken place, the students will pass this challenge with less effort that if it is planned as a single practice. Once finished the experience, a survey must be completed.

This double-stage design will result useful in a double sense: firstly, it summarizes the concepts and skills object of this block of the course content; secondly, it allows the student a general scope of the technique here presented that can help to clarify some remaining doubts. In itself this challenge

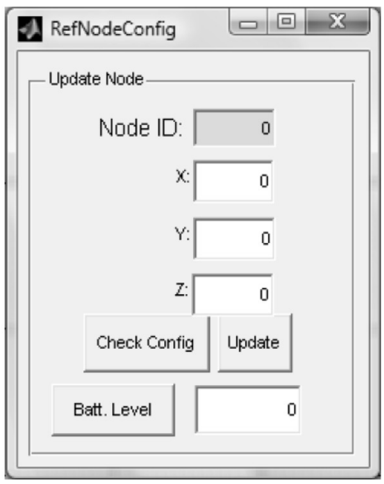


Fig. 6. Node setup menu.

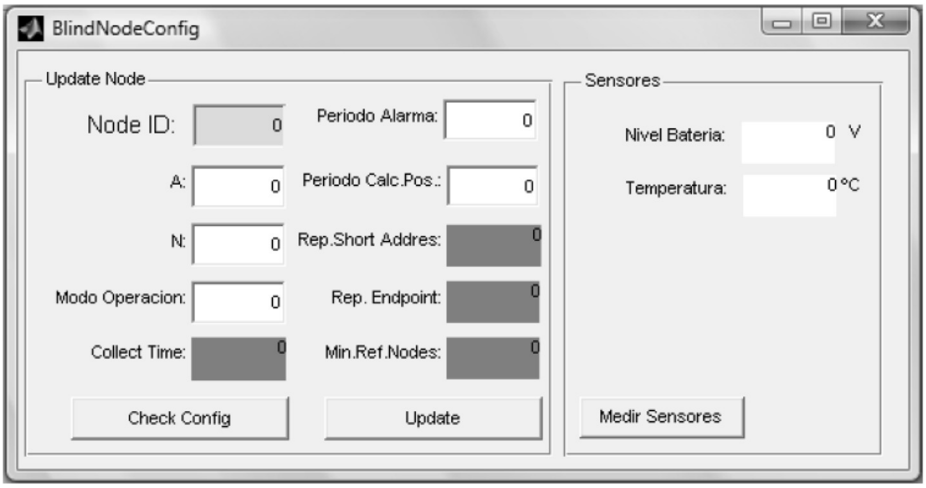


Fig. 7. Propagation model fit menu (I).

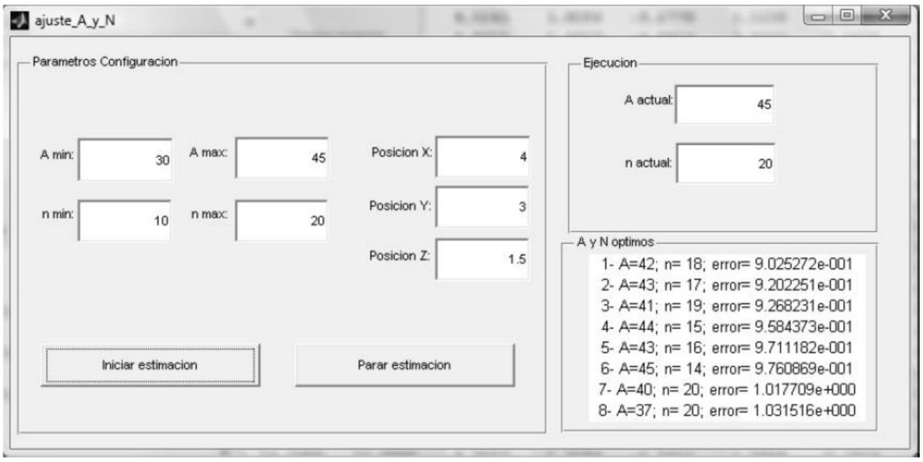


Fig. 8. Propagation model fit menu (II).

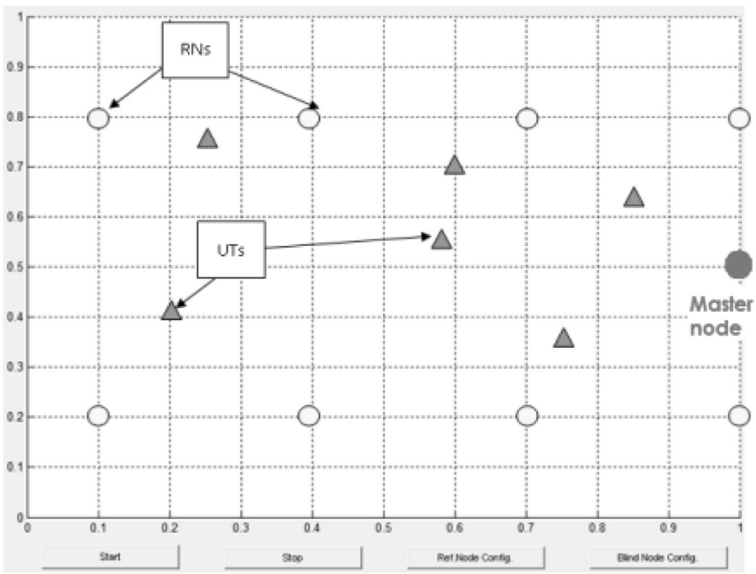


Fig. 9. Geometrical disposition of elements in the Zigbee mesh network.

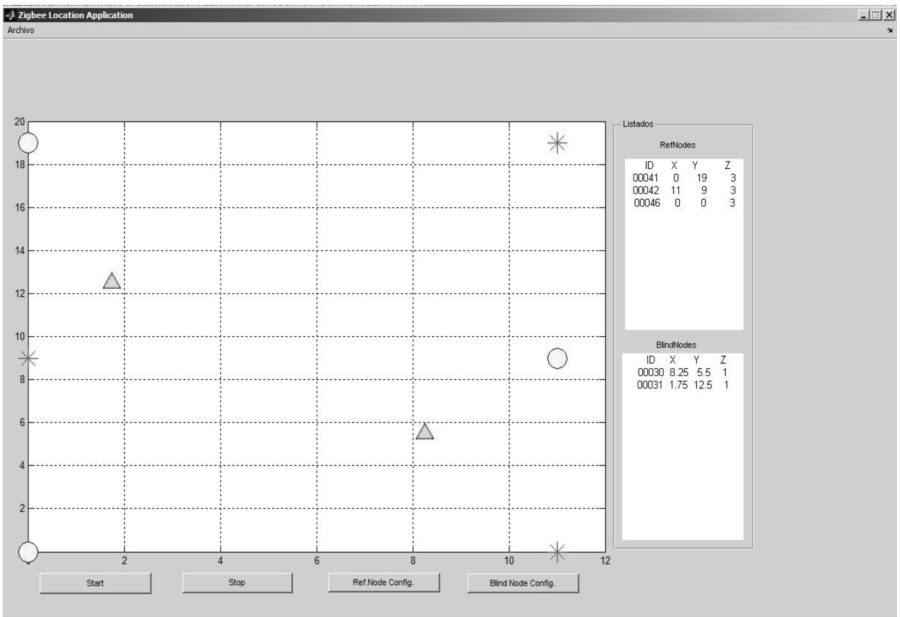


Fig. 10. Example of final challenge scenario.

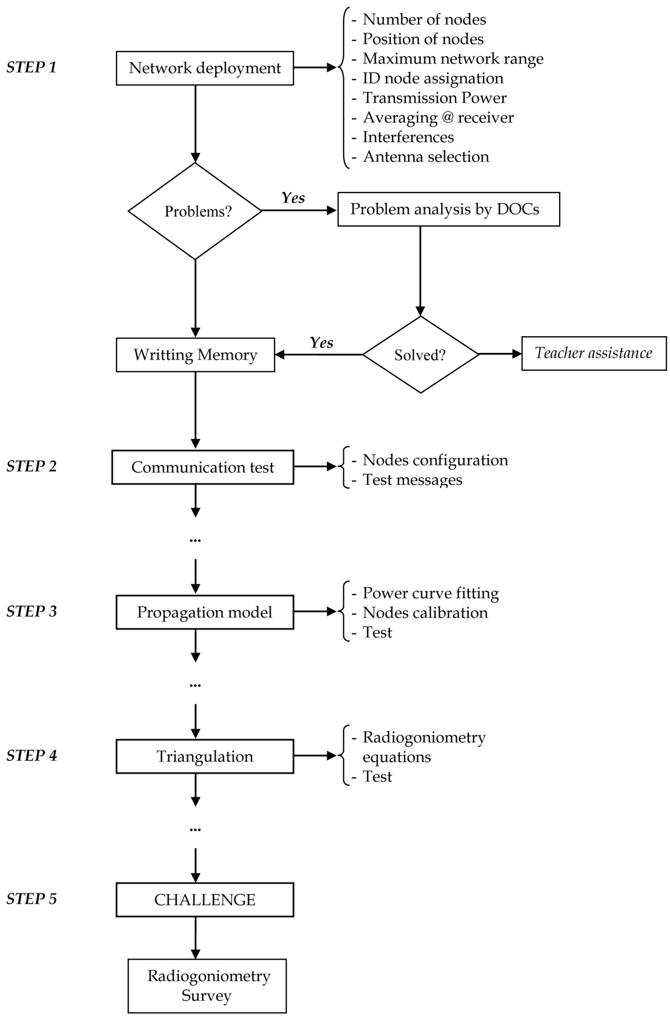


Fig. 11. Route chart

constitutes an auto-evaluation of the previously learned concepts. In Fig. 10 it can be observed one example of the scenario thought for this challenge.

The implementation is completed with the design of the smart learning route chart that provides a guide containing what is to be learned, how it is learned, when it is learned and how it will be assessed. In Fig. 11 we show the block diagram of this learning chart.

4. Assessment of the play-based experience: evaluation of results

Another not less important aspect to consider along the development of this kind of learning is the way of evaluating the acquisition of knowledge [37]. It is essential to collect information in the cognitive and in the affective dimension. This information has to be analyzed to evaluate a classical trade-off: the satisfaction level and the effective cognitive learning.

As it can be seen in the route chart of Fig. 11, the evaluation of the subject was divided in two parts. The evaluation of the theoretical contents follows an innovative method based on online surveys provided via a web educational platform that uses the open source eLearning and eWorking platform *Claroline* [38–39]. The surveys include ten short questions regarding the theoretical part and it is done after the lab practice. In Fig. 12 we can see the home page of the website dedicated to the eLearning platform. In Fig. 13 we show one question of the surveys regarding the theoretical part evaluation.

The number of students attending the subject the course 2008/09 was 70. For the lab practices, they were divided in groups of two, and later assigned to one turn controlled by a different teacher. Three blocks of practices were designed, and the experimental experience regards block #3.

Volunteers were solicited to develop this pilot experience and a total of 12 students attended the call. A different task was assigned to the students that did not participate in the lab pilot group, consisting in a documentation work to be exposed at the classroom. These works were evaluated by the rest of groups and they concern the same topic as the lab experience. The non-participating students are considered the control group.

For the evaluation of the practical contents in the pilot group a traditional method usually extended in engineering was used, consisting in the elaboration of reports regarding the lab practices. In order to

Fig. 12. Screen shot of *faitic.uvigo.es* web.

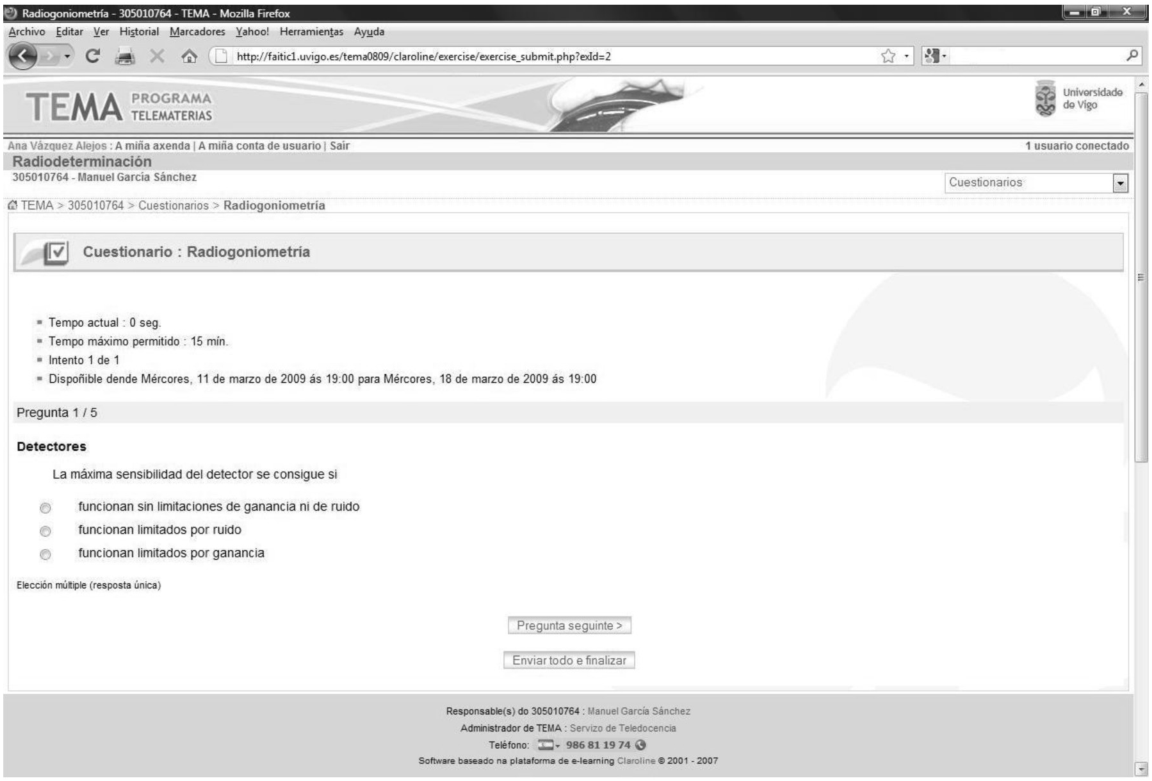


Fig. 13. Screen shot of on-line survey using *Claroline* at *faitic.uvigo.es* web.

evaluate the cognitive level, for each practice a set of questions are included in the memory to be solved and answered by the group. So, individual scores cannot be evaluated separately. This can result in an unfair score for students and does not reflect the individual effort.

The on-line survey takes place after the lab experience for pilot group and the presentation of documentation work for the control group. This survey is the same for both groups and concerns about the theoretical contents of the block #3.

In Fig. 14 we have plotted the resulting scores of lab block #3 using a boxplot representation instead of traditional scatter plotting [40]. A statistical analysis based on boxplot results a powerful tool to analyze the deviation of the individual, group and turn scores with respect to their respective medians. This simple analysis offers a good graphical inspection tool of influence factors as important as: teacher in charge of the turn, difficulty level of the practices. Students requiring reinforce can be identified.

Generally, for practical block 3, groups achieved larger scores in the pilot experience than for the documentation work as in previous years, as shown in Table 1. Among the reasons to explain this fact, we can remark that usually the level of effort is less in this kind of tasks and also the level of motivation. We have detected also that some of the works were identical to the last year. In general, the level of deepening in the topic assigned is not large and the students tend to minimizes effort and time. The result is that a 10% of the students fail this practice with scores under 5.

The success of the experimental practice can be explained also by the large level of control that the experience provides for its development. All the steps are predefined and the objectives are presented in a piecewise mode via the learning route chart, from simple to complex levels, so it results in a straightforward progress for the student.

The satisfaction level was inferred from the surveys that our institution passes each semester to every subject. The surveys demonstrated a good performance in the affective dimension. This can be inferred also from the results of pilot experience scores.

4.1 Efficiency of the through-play methodology

Among the criteria to be considered in order to evaluate the efficiency of the through-play methodology with respect to other different method, we should consider the following ones:

- resources: the economical investment (r) required to implement a play-through experience has to be compared with respect to the cost required for deploying other methodology.

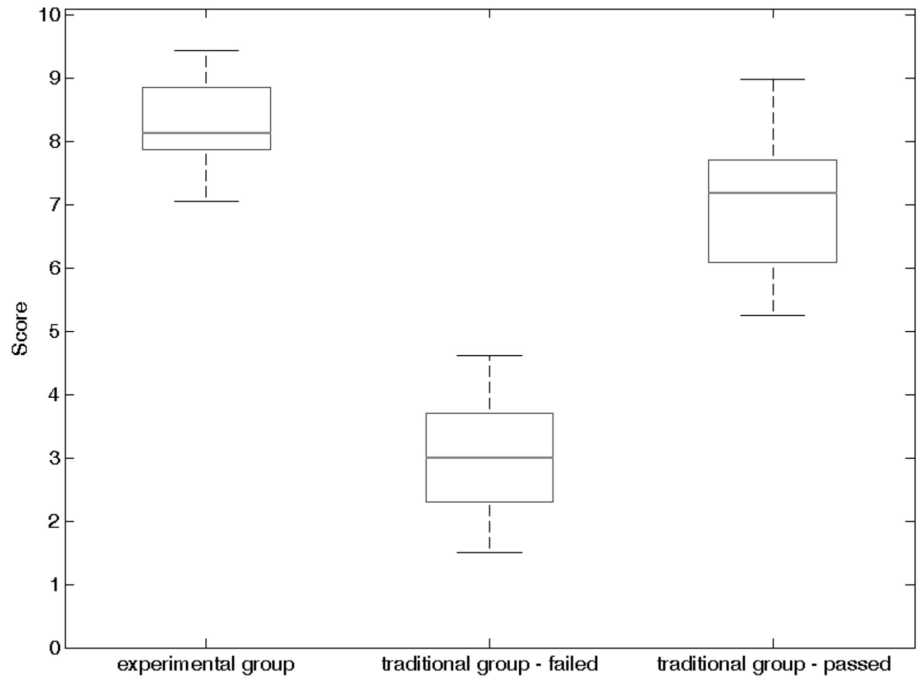


Fig. 14. Boxplot of scores for lab practice block #3.

Table 1. Score results for radiogoniometry survey taken by students not participating in the through-play experience

Year	Students survey/ total	Average score	Minimum average	Minimum average	Average time used
2006/07	43/46	3.67/5	1.55	5	11min 57s
2007/08	53/72	3.4/5	1.2	4.9	9min 44s
2008/09	42/47	3.67/5	–0.8	5	10min 44s

- time: it is needed to distinguish between the time needed for the preparation of the practice, large for the first year, the maintenance effort, and the time required for the realization of the practice in the lab or classroom. One variable can be assigned to each time: t_p for preparation-maintenance, and t_r for realization.
- results: the results obtained can be measured in terms of the score achieved for cognitive level (r_{cl}) as well as for learning motivation and affective dimension (r_a).

A formula can be established to measure the absolute efficiency of the methodology taking into account all the variables:

$$eff_{abs} = -r - t_p - t_r + r_{cl} + r_a \tag{1}$$

The same equation (1) can be given in relative value Δ_{eff}, as the difference between the play-based absolute efficiency, $eff_{abs/play}$, and the second method absolute efficiency, $eff_{abs/other}$, as in (2):

$$\Delta f_{eff} = \Delta r + \Delta t_p + \Delta t_r + \Delta r_{cl} + \Delta r_a \tag{2}$$

Dimensionless units should be preferred for all the variables, so they can be scored with respect to reference values. Weightening the different variables can be considered if it is needed to remark the importance of any of them under a particular situation.

5. Conclusions

In this paper we have analyzed one pilot experience developed at the graduate level of an engineering degree. We can state that education has evolved from a teaching to a learning focus and the incorporation of active learning is the way for this transformation. Active learning based methodologies have demonstrated to be more effective than passive learning. We analyzed that the use of active learning methodologies results largely suitable for the teaching of technical disciplines such as engineering.

We conclude that simple experimental tests can facilitate the acquisition of most important concepts that students will need to use and apply as professional engineers after the graduation. We presented the methodology developed and the material needed to carry out this practice. The pilot experience showed a large level of enthusiasm and satisfactory feeling among students. It demonstrated that the lack of fun, serious work can be done, time problems

The good results achieved encouraged the teachers to repeat the experience next year trying to introduce some novelties thanks to the developed and tested methodology and the available material, as well as the experience acquired by the teachers.

In the evaluation method, it results necessary to implement a form of differentiating the individual and the group scores in the lab practices. The design of individual surveys may be a solution and it is of easy implementation thanks to the available eLearning platforms.

In future, the learning route chart hopes to be incorporated as part of the eLearning platform, and the Open Source Course Management System, Moodle [40], seems to be a valid option to implement this learning management system.

The equation proposed to estimate the efficiency of the through-play methodology evidences that it depends of a balance between risks or disadvantages -basically resources, time-, and benefits, mainly represented by the learning results.

Even when the student's motivation principle has been occasionally hardly questioned, and in [41] we can read even a claim to leave this point as a criterion to design new teaching methods, we do not agree this abrupt claim. However, we consider that a new definition of student's motivation should be discussed not only in terms of affective dimension but also spreading it to include the learning motivation. The through-play methodology appears as a most than suitable instrument for this purpose.

Acknowledgments—This work has been supported by People Program of 7th FrameWork Programme (2008 Marie Curie IOF Action).

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