JOURNAL OF BALTIC SCIENCE EDUCATION
ISSN 1648-3898

THE INFLUENCE OF TEACHING METHODOLOGIES IN THE LEARNING OF THERMODYNAMICS IN SECONDARY EDUCATION

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Abstract. *This research has as it is the objective to show the influence of three different teaching methodologies in the learning of some basic concepts of thermodynamics with 14 and 15-year old students. This study was motivated by the scholar failure of students at these ages, especially in science. The sample was 93 students divided in three homogenous groups. Each group learnt the concepts with a teaching methodology. The concepts were density, pressure, volume, temperature and heat, these are the concepts of the curriculum. The instruments were a pretest and a posttest with theoretical questions, exercises and problems about thermodynamics concepts, moreover students made an intelligence test to verify the homogeneity of the groups. The results brought us that the teaching methodology has a very important role in the learning of the students in secondary education.*

Key words: *learning, cooperative learning, traditional methodology, technologies.*

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Introduction

The academic performance acquires increasingly relevancy for the teachers of the different educational levels (Abalde et al., 2009). The percentage of failing students and the rates of school abandon centre the research on these aspects of the education. In Spain, the rate of early abandon of the studies is near 30 , on the other hand, in the European Union (EU) around 17. In the last years the abandons on the EU has experimented a light decrease whereas in Spain they are kept constant (Roca, 2010).

What factors do this failure and school such a worrying abandon cause? There are known the predictive factors of risk (Aramendi et al., 2011): poverty, belonging to an ethnic minority, immigrants' family, ignorance of the majority language, type of school and its location, lack of social support and besides others like social and cultural characters (Serna et al., 2008). Some authors appear towards the internal relation between the school processes of learning, the performance, the success or the failure (Castejón et al., 1996; Castejón & Perez, 1998). For others, the academic goals are the preponderant factor caused by the students and their motivation or lack of motivation due to the academic results (Barca et al., 2011).

This research is going to be focused in secondary education, it is important to know that secondary students consider these studies "very boring, very much use of book and many hours of class, but what is learned does not serve for almost at all" (Vega & Aramendi, 2010, p. 13). In this stage the curriculum goes away dividing and the education becomes eminently explanatory by the help of textbooks. Guarro (2005) warns that an excessive abstraction exists in secondary studies, being too abstract problems and exercises. In relation with the learning of the sciences, the students of EU "have a positive attitude in biology in 57 of the cases, 55 in

ISSN 1648–3898

the sciences of the land, 42 towards the chemistry and 38 towards the physics " (Eurydice, 2011, p. 22). The data of PISA 2009, relative to this subject, show that in Spain the positive attitude has got down lightly respect of 2006, the knowledge is below the average of the EU, occupying the place 20th of 27 countries (PISA, 2009). Between the pre-service secondary teachers, it predominates over the idea of that the unique necessary thing to teach is the domain of the contents of the subject that is going to be taught, the teacher is a specialist of contents (León et al., 2011).

Before this information it becomes more urgent to attend to the formation of the professorship (Esteve, 2006). To change the results obtained in the science education, several suggestions exist, for instance, to develop researches on procedures of learning, to rethink the formation of the science professorship and to confront the renovation of the curriculum (Confederación de Sociedades Científicas de España, 2011; Eurydice, 2011). Before choosing for some procedures, there have been born in mind researches emphasized in science education that compare the effects of different methodologies as the traditional one, the experiment (Marusic & Slisko, 2011), the laboratory as way in order that the pupils investigate and learn (Barolli et al., 2010) and others. Therefore, it is important to change the methodology based in textbooks and comments of the teacher, without any other means, the role of the students is to take notes and to be quiet in this methodology, it is a passive role, this methodology has been used centuries ago by a lot of teachers and professors and it is called "traditional methodology" (Jiménez Aleixandre, 2000). But are the results of this methodology the best or is it possible to use another teaching methodologies with better effects than "traditional methodology"?

The Use of Technologies in the Process of Teaching and Learning Science

In the researches on the use of technologies like the computers, mobile, tablets and internet in education, it is usually being highlighted the estimable help given to the students because they increase the motivation (Méndez, 2012), they show numerous interactive experiences, supply tools as self-assessment, facilitate the communication and the cooperation, favoring the personal learning (Reimann & Goodyear, 2004). In relation with the sciences, the technologies facilitate the learning (Méndez, 2013), make possible to the students the overcoming of alternative conceptions, increase the autonomy of the students, provide sets of information and presentations, allow to relate easier the learned to the real life and improve the skills of resolution of problems and exercises (Egarievwe et al., 2000; Webb, 2005).

In spite of the mentioned advantages that the use of technologies in class offer, they do not use with the due frequency (Clares & Gil, 2008), due to "the complexity of the process of use and integration of the computers in the school systems, submitted to tensions and pressures proceeding from multiple authorities" (Area, 2010:80). Nevertheless, the integration of the technologies is evaluated favorably in diverse countries, not only in the science class but also in mathematics (Perkins, 2011; Howie & Blignaut, 2009). In thermodynamic some technological tools have used, for example the LabView, which improves the learning (Quiñonez et al., 2006), the use of videos (Lee & Sharma, 2008), in addition the development of didactic units is taking major importance, using simulations, programs and virtual laboratories (Donnelly et al., 2011; Sandoval, 2011; Rodríguez-Llerena & Llovera-Gonzalez, 2010; Al-Daihani, 2011).

Therefore, the use of computer and internet can facilitate the learning of the students, especially in the contents of thermodynamics of secondary education, but this effect can be very little, therefore it is not very useful in education.

The Cooperative Learning in the Process of Teaching and Learning Science

In reference to the cooperative learning it has to be considered some knowledge and interesting characteristics for the organization of the formal groups - groups that they remain during several classes- where the students worry so much about their learning as about that of their companions. There might be highlighted five features (Bará, Domingo & Valero, 2005; Velázquez et al., 2010; Woo Nam & Zellner, 2011):

1. Positive interdependence: a student thinks that he is not to have successful if the remaining components of the group do not achieve it and vice versa.

2. Positive interaction: the students explain to themselves mutually the concepts and the way of solving problems.
3. Personal responsibility: the teacher must evaluate the personal efforts of every student.
4. Cooperative skills for the effective functioning of the group: capacity of leadership, to take decisions and to generate confidence.
5. Self-analysis of the group: discussion inside the group to know in what degree the aims are achieved.

Researches on the cooperative learning show the efficiency and advantage in the classroom (Johnson & Johnson, 1999), "nevertheless, the use of the cooperative learning is absent in the classrooms" (León et al., 2011:725), though some investigations have been realized successfully with regard to the application in language education (Ábalo, 1998), in mathematics (Gavilán, 1997) and in the education of the fiscal system (Alarcón, 2009).

In science the cooperative learning has been applied to the design of classes based on researches (Bell et al., 2010), to the study of the magnetism (Tanel & Erol, 2008), and the same strategy was used in the individual learning to solve problems of physics (Harskamp & Ding, 2006). Moreover the cooperative learning increases the motivation (Korkmaz, 2012). All of these have achieved good results.

Therefore, the research is going to be focused in the effect of cooperative learning and the use of computer and internet in the classroom. The "traditional methodology" is very used in the class today (Jiménez Aleixandre, 2000) but the results of learning are not too good. Then, is it possible to change these results with the cooperative learning and the integration of technologies? And how much will this effect be?

Methodology of Research

For the results of the process of teaching-learning, which allows to reach the proposed aims, there was designed a strategy integrated by three methodologies: the first one was the group of control named a "traditional group", it is the group that followed the traditional methodology; the cooperative learning was applied in the "cooperative group" and in the third group the technologies were used and was named the "group TIC".

In the traditional group, the teacher and the students had the textbook, the blackboard and the notebook. The teacher was explaining and the students were taking note. In the cooperative group, the teacher was helping himself with the blackboard and with audio-visual means, with animations in java with Internet and videos. The teacher explained ten minutes per class, afterwards the students worked 40 minutes at groups some tasks given by the teacher. In the group TIC, the teacher was explaining exclusively with videos, animations in Java and Internet pages. The student was paying attention, was taking notes and was working individually. The explanation of the teacher lasted 40 minutes per class and the individual work 10 minutes approximately.

The research focused on the concepts of density, pressure, volume, temperature and heat, these are the thermodynamic concepts of the curriculum of 14 and 15-year old students. In the curriculum it is not included concepts like entropy or Clapeyron diagrams. The pressure, volume and temperature include the Boyle, Charles and Guy Lussac laws. The heat includes the transfer of energy, the graph of warming and specific heat.The results of the students usually are not very good, perhaps because the teaching methodology did not facilitate the learning. It is important to notice two aspects: it is an obligatory subject in the curriculum and the same theoretical and practical contents were explained in three groups.

Goals of the Study

The goal is to notice the effect of teaching methodologies in learning of the basic concepts of thermodynamics in 14 and 15-year-old students. In this case the teaching methodologies are three: cooperative learning, the use of technologies and traditional methodology. This goal includes these objectives:

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1. To verify the homogeneity of the groups.
2. To check the existence of alternative conceptions on the investigated concepts.
3. Compare the results of the process of teaching-learning in three groups respect of the theory, the exercises and the problems of physics.
4. To evaluate the degree of efficiency of the learning cooperative and the technologies in the learning of the concepts of the thermodynamic one: density, pressure, volume, temperature and heat.
5. Finally, to identify, between the studied procedures, with what method the students obtain a *better learning.*

Sample

The sample was formed by all the students of 14 and 15 years of the school center that they had to deal necessarily the subject of Physics and Chemistry. The students supported a positive or negative attitude opposite to the sciences.

The teacher was the same in the three groups. The thermodynamic concepts were worked for the first time this year by these students.

The students were distributed by the school two years ago in three classes by the purpose of looking for the major homogeneity. The groups consist of 33, 32 and 28 students. The group that has followed the traditional method is that of 33 students, chosen because the classroom did not have audio-visual resources. The cooperative group, of 32 students, was the group best known by the teacher, interesting aspect in the organization of the groups inside the class (León del Barco, 2006), in addition the means of the classroom were making possible the utilization of audio-visual means. The group TIC was that of 28 students, known for the teacher and whose classroom was making the employment of the TIC possible. The sample is 93 students, therefore it is possible to include in the category of quasi experimental study (Minner et al., 2009).

Instruments

The instruments used for the research were the following ones:

1. The intelligence test BTDA-2 the types of intelligence measured up: general, abstract reasoning, verbal and numerical aptitude and spatial intelligence with a reliability from 0,75 to 0,92. The ends of the scale are 1 and 99.
2. A test of knowledge with 17 questions, three have two parts, in consequence 20 answers: four of theory, five exercises and eleven problems. Five referred to the density, six to the pressure, volume and temperature and nine to the heat. The test was of own elaboration. After this elaboration, the test was validated by two physics professors and three education professors, and five of the school center with more than ten years of experience. The teachers punctuated the questions, this punctuation was from 1 to 5, the finally selected questions had a punctuation over 4. The reliability was studied: the results of Cronbach alpha (1951) was of 0.71 and according to Spearman-Brown's method of 0.73. On having been an academic test, these values assured the reliability of the instrument (Thorndike, 1989; Magnusson, 1982).
3. The teacher took note of the classes, he asked students about the contents for 5 minutes at the beginning of the class and he corrected homework every day.
4. The materials with which it developed and supported the explanation of the basic concepts of the thermodynamic one were an object of meticulous design, preparation, elaboration and test in the previous year.

Process of the Research

This research has double preparation: The materials were prepared by an education professor and the physics teacher for the mentioned concepts of the curriculum, the first year that the students have to study the subject of Physics and Chemistry, unique with dense content of physics and obligatory for all the students. The materials prepared to teach the contents, according to the strategy of the cooperative learning and by means of the use of the technologies, they were checked and fitted by university professors and physics teachers of the school in which it was decided to realize the experience. There were prepared the pretest and posttest of knowledge, checked by the same professors and teachers, there being established the order of the questions and the punctuation for every response. Another most nearby preparation consisted of deciding the group to which to apply every methodology, criteria of organization of the groups of class in the "cooperative group" and the plan of the tests and explanations.

The groups in the cooperative class were formed by three students, always there was a student of the top third of the class and other one of the low third having in it counts the global previous year marks.

The intelligence test BTDA-2 was done by the students in the second week of year, in September, 2010. The students realized the pretest two weeks after the test BTDA-2 to foresee with time, if it was necessary, to adapt some part of the foreseen material, known the alternative conceptions of the students. In the last week of October it began the explanations to develop in the five following weeks, the teacher also took note about the behavior of the students. At the end of the experience, the three groups realized the posttest simultaneously, each one in their classroom. Therefore, the duration of the experience, included all the tests, was six weeks.

The data are shown in two scales, the intelligences have a scale from 1 to 99 and the results of the questions are from 0 to 1. To compare the results of the three groups it is going to be used the ANOVA, this statistic is used in the researches of major rigor (Minner et al., 2009).

Results of Research

The first checking was the homogeneity of the groups. The opinion of the teachers seemed to us to be important. There were polled the teachers who were giving them lessons or who had given them lessons in last two years it brings over of if they were the equal groups or not, simply their perception, they were teachers with experience, of at least five years. They assured that the group TIC could be a bit worse intellectually and their marks were lower than those of the other groups, nevertheless other two groups were practically equal. In favor of a more objective checking, there passed the intelligence test that showed the following results:

Table 1. Information of the intelligences of the students according to the group. (The results vary from 1 to 99).

Group	General intelligence	Abstract reasoning	Verbal aptitude	Numerical aptitude	Spatial intelligence
Traditional	56.2+21.0	58.8+27.0	58.3+24.2	59.1+23.8	59.3+30.3
Cooperative	56.8+21.0	57.5+25.3	58.9+18.5	59.3+22.9	59.1+24.5
TIC	49.7+20.8	41.3+27.7	55.6+24.5	50.4+21.5	60.1+26.8

The ANOVA does not reveal significant differences, the value of the F is 0.003 and the F (1) is 0.01. With the information obtained in the intelligence test and the opinion of the teachers demonstrates the homogeneity of the two groups, traditional and cooperative, and the little difference with the TIC group.

Before the research there was completed a pretest, showing them the different alternative con-

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ceptions that the students of physics and chemistry, of 14 and 15 years, possessed with regard to the thermodynamic one. They can be synthesized in the following ones:

1. Almost 60% of the students affirm that the warm air weighs less, not that it is less dense.
2. 67% of the students confuse the concepts of pressure and force.
3. When two substances are mixed to different temperatures they add or substract the initial temperatures of the substances.
4. 50% of the students think that the materials have a maximum temperature and already they cannot warm up any more.
5. They say that the temperature of boiling depends on the quantity of substance of this material.
6. 40% of the students affirm that heat is the same as temperature, 10% say that heat is absence of cold.
7. 50% of the students expose that during a change of state the temperature continues increasing and being not constant ever.

Another data was the observation of the teacher during the classes: he ordered homework to do in house, asking of oral form to the beginning of the class, with the purpose of investigating how the students were assimilating the explained concepts, the teacher asked them several situations like in the test. The results were the following ones:

Table 2. Results of the observation of the teacher during the period of explanation.

Methodology	Correct answers (%)	Lack of homework (%)	Perception
Traditional	24	18	Boring
Cooperative	62	16	Attention and good use of the time
TIC	63	21	Attention but boring at the end of the class

New information on the homogeneity of the groups is inferred of the will of work reflected in the lack of homework: the pupils have a similar capacity and the lack of homework is practically equal. On the other hand, the differences are significant in the assimilation of the contents and in the observed sensation. According to the teacher, in case of the cooperative group, it seemed that "the class was remaining short for the students" and in the group TIC with the explanation of the teacher "the class was making to them a bit long", therefore the traditional group did not take advantage of the lessons as other groups. The classes lasted one hour.

When the students were evaluated at the end of the explanation, the results showed the percentage of correct answers of the set of students who compose every group. On having made concrete the given punctuation to every response, the teachers of the school center and the university professors agreed the punctuation that would devote itself to partially correct answers, since, treating about opened questions, a developed response is asked. However, in the multiple choice questions they agreed to value only the correct answers.

The results of the theory questions were the following:

Table 3. Results of the theory questions according to the methodology.

Questions	Traditional	Cooperative	TIC
Question 1	0.91	0.97	0.82
Question 2	0.38	0.79	0.66
Question 3	0.21	0.84	0.89
Question 4	0.68	0.81	0.88

The question 1 was easy for all the students. For pedagogic reasons the teachers insisted on that the test should begin with the minor's questions to major difficulty, especially the first one is usually the easiest of the test. As for the answers of the remaining questions, the significant difference is between the groups TIC and cooperative opposite to the traditional one. It is obvious that in the assimilation of the theory they have had great influence the methods followed in the explanations, on the other hand, the results of the cooperative one and the TIC do not differentiate.

Now it is going to show the exercises results:

Table 4. Results of five questions of exercises according to the methodology.

Questions	Traditional	Cooperative	TIC
Question 5	0.32	0.55	0.69
Question 6	0.24	0.63	0.64
Question 7	0.42	0.78	0.71
Question 8	0.15	0.81	0.71
Question 9	0.48	0.60	0.56

The results achieved by the students of the traditional group were very low compared with those of the cooperative and TIC groups. In spite of it, the teachers said that the results of the traditional group were the usual results in this part of the subject. The results of cooperative group are similar than the TIC group.

Thirdly there appear the results of the problems, which constitute decisive indicators in the comprehension of the physics:

Table 5. Results of eleven problems.

Questions	Traditional	Cooperative	TIC
Question 10	0.08	0.33	0.09
Question 11	0.38	0.33	0.30
Question 12a	0.85	0.81	0.86
Question 12b	0.79	0.75	0.61
Question 13	0.63	0.63	0.52
Question 14a	0.49	0.67	0.45
Question 14b	0.18	0.46	0.20
Question 15	0.45	0.68	0.57
Question 16	0.34	0.35	0.44
Question 17a	0.15	0.56	0.29
Question 17b	0.14	0.53	0.29

In the questions of theory and in the exercises, the cooperative group and TIC always had achieved a similar punctuation and higher than the traditional group. On the other hand in the problems, the results of the traditional group are similar to those of the group TIC and there is minor differs with regard to the cooperative group. In addition, the cooperative group is the best in eight cases, the group TIC only in two and the traditional one in three. In consequence, it seems that in the evaluation of problems the difference diminishes clearly between the group TIC and the traditional one and a bit with the cooperative one.

Now it is possible to observe the general results of theory, exercises and problems.

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Table 6. Results of the final test for groups depending on every part.

Group	Theory	Exercises	Problems
Traditional	0.54	0.32	0.41
Cooperative	0.85	0.67	0.55
TIC	0.81	0.66	0.42

It is observed: the cooperative group obtains the best results, followed by the group TIC and thirdly the traditional one. The differences are very significant in the theory and in the exercises and diminish particularly in the problems. In fact, between the group TIC and the traditional one there is no scarcely difference in this part of the test.

In the analysis of the theory, ANOVA gives a result for F = 21,500, and the F (1%) = 4,881. Therefore, these results reveal significant differences.

In the analysis of the exercises, the F= 29,102, the F (1%)= 4,881. The differences are significant. In the analysis of the problems, the F = 24,585, the F(1%))=4,881. Therefore, the results of the problems are significantly different.

To check the attainment of the fourth aim of the investigation there were distributed the results of every question by concepts: density, the pressure, volume and temperature and the heat. It begins for the results to the questions of the density.

Table 7. The results of five questions referred to the concept of density.

Questions	Traditional	Cooperative	TIC
Question 3 (Theory)	0.21	0.84	0.89
Question 7 (Exercise)	0.42	0.78	0.71
Question 11 (Problem)	0.38	0.33	0.30
Question 17a (Problem)	0.15	0.56	0.29
Question 17b (Problem)	0.14	0.53	0.29

The information on the previous table shows that the students in the cooperative group and of the group TIC have assimilated better the concept of density both in the theory and in the practice. The differences are significant between the results of the traditional group and another two. Between the cooperative group and the group TIC, the results are similar in the theory and in the exercises, on the other hand in the problems, the students who have followed the cooperative learning overcome notably those of the group TIC.

The results of the questions on pressure, volume and temperature are.

Table 8. The results of five questions referred to the pressure, volume and temperature.

Questions	Traditional	Cooperative	TIC
Question 1 (Theory)	0.91	0.97	0.82
Question 2 (Theory)	0.38	0.79	0.66
Question 5 (Exercise)	0.32	0.55	0.69
Question 6 (Exercise)	0.24	0.63	0.64
Question 10 (Problem)	0.08	0.33	0.09
Question 16 (Problem)	0.34	0.35	0.44

The results of the traditional group are lower than cooperative and TIC results. It cannot be appreciated, on the other hand, notable differences between the results of the students of the cooperative group and those of the TIC.

The results of the questions that have relation with the heat concept appear in Table 9.

Table 9. The results of nine questions referred to the heat concept.

Questions	Traditional	Cooperative	TIC
Question 4 (Theory)	0.68	0.61	0.88
Question 8 (Exercise)	0.15	0.81	0.71
Question 9 (Exercise)	0.48	0.60	0.56
Question 12a (Problem)	0.85	0.81	0.86
Question 12b (Problem)	0.79	0.75	0.61
Question 13 (Problem)	0.63	0.63	0.52
Question 14a (Problem)	0.49	0.67	0.45
Question 14b (Problem)	0.18	0.46	0.20
Question 15 (Problem)	0.45	0.68	0.57

Respect of the heat concept, the traditional group reaches results near to those of the group TIC and lower than those of the cooperative group that achieves the best results, with a very high percentage of right answers.

Now it is possible to observe the general results of theory, exercises and problems.

Table 10. The results of the final test according to the groups and the evaluated concepts.

Group	Density	Pressure, volume and temperature	Heat
Traditional	0.26	0.38	0.52
Cooperative	0.61	0.60	0.69
TIC	0.49	0.59	0.57

The results of the traditional group are the worst again, those of the group TIC improve notably these results and the cooperative group obtains the best results in all the cases.

In the analysis of the results of the density, ANOVA gives a result for F = 28,354, and the F (1%) = 4,881. Therefore, these results reveal significant differences.

In the analysis of the results of the questions about pressure, volume and temperature, the F= 37,609, the F (1%)= 4,881. The differences are significant.

In the analysis of the questions related with the concept of heat, the F = 40,157, the F(1%))=4,881. Therefore, the results of the problems are significantly different.

To illustrate the differences with some questions, it is shown one exercise of the test, it took from the book of Driver et al. (1989), number 8.

A material gets an oven that is to 1000ºC and the temperature of the material is: 20 º, 30 º, 70 º, 200 º, 360 º, 420 º, 420 º, 420 º … ¿ What will happen?

a) The temperature of the material will remain in 420º.
b) The temperature of the material will come to 1000º.
c) Do not know.

If it is calculated the gaining according Hake (1998):

$$g = \frac{s_{post} - s_{pret}}{100 - s_{pret}}$$

ISSN 1648–3898

Being gain of learning, the percentage of right answers in the posttest and the percentage of the right answers in the pretest.

The gain of learning in one of the exercise of the test was 0.08 for the traditional group, 0.67 for the cooperative and 0.50 for the TIC group.

In this case, the conceptual change is observed clearly in the cooperative and TIC groups, nevertheless in the traditional group it is not observed.

And now, to illustrate the same the result of a problem is going to be shown, this problem has taken of Driver et al. (1989).

You have a scale with two plates: I place a closed flask full of air on the right plate and a weight on the left in order that the scale is in balance. I leave the equipment to the sun and observe.

a) The flask will weigh more than the weight.
b) It will continue in balance.
c) The flask will weigh less than the weight.
d) Do not know.

The gain of learning referred to this problem was 0.06 for the students of the traditional group, 0.51 for the cooperative and 0.20 for the TIC. Therefore, it is possible to say that some students who were thinking in a certain way, in spite of the explanations that they received, they return to give the same response. In case of the cooperative group, the students achieve a conceptual change, nevertheless in other two groups the conceptual change affects few students. In fact the majority response in these groups is the C, that is to say, that the air boat weighs less because the air weighs less on having warmed up, alternative conception that they had exposed previously, "the warm air weighs less, not that is less dense ".

In view of the exposed information and having in it counts the found differences, the cooperative group has had a more quality learning. It is possible to be interesting to know also the general results of the test, with 20 questions. It might obtain the general qualification of the test of three forms:

1. To give the same value to every question, 5, to obtain 100 on having added 20 answers of the test.
2. To obtain the results for concepts, assigning to each one the weight of a third of the final qualification. Therefore, every concept would have the same value.
3. To obtain the results on parts and that every part - theory, exercises and problems - have the weight of a third of the final qualification. Therefore, every part of the test would have the same value.

Table 11. The results of the final test according to the groups and the evaluated concepts.

Group	Each question has the same value	Each concept has the same value	Each part has the same value
Traditional	0.41	0.39	0.43
Cooperative	0.62	0.63	0.69
TIC	0.55	0.55	0.63

It appreciates that the different forms of evaluation do not show big differences with regard to exposed in previous results: the cooperative group obtains the best results, secondly one finds the TIC and thirdly the traditional one. It is demonstrated that the differences are not a consequence of the evaluation, but of the methodology that has followed in the classroom at the moment of explaining the diverse concepts.

To see if the differences owe at random, we use the analysis of variance that serves to compare several groups (Bernardo and Calderero, 2000). In this case, we take a level of significance of 5 and suppose that "the difference owes at random", with this situation the value of the Snedecor F is 14,35 for the groups and students of the experiment.

Table 12. Analysis of variance according to the learning of the groups of students.

Meaningful level	F	Comparison	Interpretation
5%	3.13	14.35>3.13	It does not owe at random.
1%	4.881	14.35>4.881	It does not owe at random.

Finally, the result of gain of the test is going to be shown divided in the parts studied during the article.

Table 13. Gain of learning according to the methodology.

Contents	Traditional	Cooperative	TIC
Theory	0.39	0.76	0.75
Exercises	0.15	0.53	0.51
Problems	0.26	0.44	0.28
Density	0.08	0.48	0.36
Pressure, volume and temperature	0.23	0.47	0.45
Heat	0.36	0.57	0.43
General test	0.26	0.49	0.44

With these results, the cooperative group has achieved the best results of learning, second the group TIC and third the traditional.

Discussion

This research can be very useful for the physics teachers and professors at present, today all public administrations in Europe are seeking to endow the classrooms of audio-visual means (Eurydice, 2011), nevertheless in many occasions the process of integration of the technologies in the classroom is not done tidily (Broc, 2010; Vázquez, 2011), in this case the material was developed and planned with time tidily, and the gain has been very positive. It is even more important because the methodology nowadays is the traditional one, therefore it is possible to observe that the effect on learning is very positive in comparison with the traditional teaching.

Today, in addition, the European Commission proposes reforms in the education methodologies, in order to improve the learning of the students of sciences, two proposals are the cooperative learning and the integration of the technologies in the class (Eurydice, 2011). Therefore, it is a study of great current importance that introduces exactly these two methodologies and show that the result is positive.

It is very important to investigate the methodologies that enhance learning for the own development of the teachers and professors, in this case the results have shown that cooperative learning and the integration of technologies to achieve a great improvement. However, it is good to compare the results with other investigations about cooperative learning and the integration of technologies in physics teaching.

Hake (1998) obtained data from mechanics tests administered 6500 students and he found that traditional classes have an average normalized gain equal to 0.23 in one semester, however interactive methods get an average gain of 0.48, even some exceed 0.70.

The gain of the cooperative learning in Physics with university students is from 0.49 to 0.82, in these cases the period of time between pretest and posttest is four months, nevertheless the traditional methodology achieves a gain from 0.23 to 0.26. When it is only an instruction for two months, the gain of cooperative learning is from 0.14 to 0.25 and the gain of traditional is 0.08 to 0.11 (Crouch & Mazur, 2001; Hänze & Berger, 2007; Desbien, 2002).

With secondary students, applying the cooperative learning for three months or more to the me-

ISSN 1648–3898

chanics teaching, the gain is approximately 0.40, nevertheless in some cases they have had a gain of 0.55 (Brewe, 2002). In our case, the gain of the cooperative learning has been 0.49 and the traditional one 0.26. Therefore, with less time it has been possible to achieve very similar results in thermodynamics.

In case of the new technologies, MIT used a tutor called CyberTutor, it "*behaves like a Socratic tutor, offering students help upon request in the form of hints and simpler subproblems*"(Morote & Pritchard, 2002:3). With this tool, the results indicate a gain of 0.55 in mechanics with engineering students. In our case the gain achieved without so many tools has been 0.44 in thermodynamic with secondary students. Therefore, it is possible to say that the gain is worse but much better than the gain of the traditional methodology.

When the results are divided according to the type of questions: theory, exercises and problems; it is interesting to observe that the gain of cooperative learning always is the best of the three methodologies, the results of TIC are the second and the third one is the traditional teaching. Nevertheless, it is crucial to observe that the difference is very little between the TIC and the traditional one of the results of the problems of thermodynamics. On the other hand, the cooperative group continues with the best result with difference in this part of the test. The cooperative learning produces a better gain in each part of the test. But the TIC achieves a very good result in theoretical questions and exercises, therefore it facilitates the learning of the students.

In consequence, with few devices, the cooperative learning and the lessons with the help of projector and animations can improve the learning very much, it would be interesting to do these experiences with students of other ages and in other subjects or, in Physics, in other areas.

Conclusions

All the 14 and 15-year-old students have to study compulsorily Physics and Chemistry, in this subject there is a part of thermodynamics, this part includes basic concepts: density, pressure, volume and temperature and heat, all these concepts are studied at the level of secondary education, a basic level. In this situation it is possible to conclude that the cooperative learning and the use of technologies have facilitated the learning more than the traditional methodology, in relation with the basic concepts of the thermodynamic one in this case.

The homogeneity of the groups has been verified by the information of intelligence test, the opinion of the past and present teachers of these groups and the observation of the work of the students during the experience.

With the pretest it has remained demonstrated the second goal, the existence and rooting of alternative conceptions. Of the results six types are inferred of alternative conceptions in the area of the thermodynamic one.

The cooperative learning and the use of technologies facilitate the learning of basic aspects of the density, of the relations between pressure, volume and temperature, and of the heat concept, though the cooperative learning has a major influence that the employment of the technologies.

The cooperative learning and the use of technologies facilitate clearly the learning of the theory and of the exercises. On the other hand, at the moment of solving the problems, the use of technologies does not cause differences with regard to the traditional methodology. Nevertheless, the cooperative learning achieves a better learning in the problems.

The students who have followed the cooperative learning reach a better result in the final test independently of how it is evaluated. Therefore, the cooperative learning has facilitated the assimilation of the studied concepts. Secondly, the students of the group TIC gets the second place and, third, the students of the traditional group.

The cooperative learning facilitates the conceptual change, the use of technologies makes easier the overcoming of the alternative conceptions, but not in all the cases, nevertheless the traditional methodology scarcely causes changes in the conceptions of the students.

To conclude, the result of the methodological experience has been so satisfactory that it can turn into an alternative for the education of the thermodynamic one. It would be very interesting that it could have an application generalized in similar situations.

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Received: *October 02, 2012* Accepted: *January 05, 2013*

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