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Promoting Inquiry Based Learning through Entertaining Science Activities

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Abstract

Considering students' increasing lack of interest and motivation for science subjects, it becomes almost imperative to introduce different methodology approaches in classrooms. Besides, decontextualized science teaching, where hands on activities are not sufficiently taken into account, can make the students attitude toward science-learning even worse. Inquiry Based Learning where elements such as games, toys and short experiments are included is showed as a useful methodological proposal. This paper presents how the use of these entertaining science activities can improve students' interest and encourage them to speak about science, acquiring better argumentation and inquiry skills when they are properly performed in a formal classroom context.

Introduction

In Europe, secondary school students' lack of interest for scientific matters is a general attitude that has been confirmed by several research studies (Rocard et al., 2007; Solbes, Montserrat & Furió, 2007). According to the mentioned study, «the origin of this situation lies mainly in the way science is taught», including aspects as teachers' motivation (Keller, Neumann, & Fischer, 2017, Bal-Taştan et al., 2018). So, it is a complex and multifaceted phenomenon, in which the way science is being taught, is one of the issues, but there are also other variables, such as the decontextualized image of science, gender issues; girls do not study Physics, Mathematics, Engineering, (Walan, 2021), especially in some parts of the world, (Ullah, Ullah, & Allender, 2020), and the status of science within the education system, among others (Solbes, Motserrat & Furió, 2007).

Thus, the decontextualization of Science was the starting point for the STS (Science, Technology and Society) projects, which confirmed that students' interest grows with these kinds of projects (Solbes & Vilches, 1997). However, the contribution of entertainment aspects of science to students' interest and motivation have scarcely been studied (Kubli, 2007, Sahin, 2020). Nevertheless, the approach to scientific knowledge from a recreational perspective is present in the origins of *modern science* itself. During the XVIII and XIX centuries, entertainment and education used to intermingle in a variety of settings from academic circles and private meetings of nobles and magnates to popular fairs, shops and even street shows (Bensaude-Vincent & Blondel 2008; Lachapelle, 2009).

The role of science activities with entertaining components within formal education in Spain has been explored in some studies (Solbes, Lozano & García-Molina, 2008; Robles et al., 2015). These exposed that this "approach" to science remained far from Spanish classrooms, perhaps missing the opportunity to overcome the question stated above. These studies also showed that students considered scientific subjects boring and too theoretical and in many cases, they did not see the "connection" between *entertainment* and *science*. Paradoxically, "outside" the classrooms, this type of connection between science and fun is becoming more and more popular and in demand (as shown in the constant rise of participants and visitors to each new edition of sciences fairs, TV shows with fun science sections, web sites with fun experiments, etc.).

On the other hand, one of the common science teaching approaches with high degree of success, according to various authors and reports, are those based on inquiry (IBSE: Inquiry Based Science Education, National Research Council, 2000; Osborne & Dillon, 2008; Rocard et al., 2007). They choose to follow these methodologies due to their advantages in motivating students and promoting science learning and scientific activity. It is intended that students participate in the processes of reasoning and construction of knowledge, usual activities of science work (Chinn & Malhotra, 2002). Therefore, in the present study, the authors approach the question of researching the effectiveness of using inquiry based learning supported by science activities with an entertainment component as a motivating element towards the study of scientific subjects in secondary schools classrooms developing inquiry and argumentative skills.

Theoretical Framework

In research developed so far on the motivation, there are numerous studies that try different approaches in order to define it, according to: the different contexts or learning materials, students' personal situations, the individual qualitative changes, the priorities, the values of effort and commitment, the behavioral code, etc. (Bong, 2004; Claxton, 1984; Ames, 1992; Green, 2002; Paris et al., 1994; Pintrich, 2006; Irvine, 2018). Nevertheless, it is usually interpreted motivation as "a behavior oriented towards learning" (Palmer, 2005).

It is unquestionable that the issue of students' motivation towards the learning of any science subject is a major concern for teachers (Solbes & Vilches, 1997). It seems clear that the interactions and contextual aspects found in the classrooms must be taken into account. The actors on the stage that are involved in the process (teachers, pupils and methodology) contribute (Boekaerts, Pintrich & Zeidner 2000; Pintrich & Schunck, 1995), and show the impact of social and contextual variables in the cognitive and motivational aspects (Järvelä, 2001; Pintrich, 2003). In this regard, not without reason, the constructivist approach explores the way in which tasks, authority and assessment are constructed through the dynamic interactions of those present in the classroom (Blumenfeld, 1992).

The lack of interest in science and technology in secondary education is a proven fact (Vázquez & Manassero, 2009). However, it is curious that this attitude is not shown in the previous school years (Robles et al., 2015). Thus, it is noted a change in attitude, which goes from a globally positive vision at the preadolescence stage to an "almost" rejection by the end of compulsory education (16 years old), and at different stages depending on several variables (gender, geographical, social, economic, etc.) (Osborne, Driver & Simon, 1998; Osborne, Simon & Collins, 2003; Parkinson et al., 1998; Ramsden, 1998; Weinburgh, 1995; Pell & Jarvis, 2001; Murphy

& Beggs, 2003; Archer et al., 2017).

As stated above, the possible reasons that affect and worsen the situation are many and varied, but it seems that the common ground can be found in the students' perception of science lessons as boring and tedious. From our point of view, this negative perception, closely linked to a lack of motivation, is related with "how" learning takes place in this stage. The ROSE project (Schreiner & Sjøberg, 2004; Sjøberg & Schreiner, 2010) tried to clarify these problems for some years by gathering data from different sources through a questionnaire (Sarjou et al., 2012; Vázquez & Manassero, 2009; Jenkins & Pell, 2006). Among their conclusions –some paradoxical, such as the recognition from students of the importance of science and technology in their daily life, together with a denial of learning about them, which is clearly expressed in their words "*important but not for me*" by Jenkins y Nelson (2005). An analysis of the data and the comparison with those from previous studies point to what has been commented above:

> "*As courses progress higher up the school, it seems that school science is perceived as more boring, less interesting and not so easy… the message for the secondary science classes seems clear: to offer a school science that is less boring and more accessible*" (Vázquez y Manassero, 2009).

Thus, evidence suggests that the activities for science lessons capable of producing a remarkable cognitive improvement in students' learning should motivate and be conceptually rich, varied and different. These activities have to raise the level of students' interest in search for answers, but without being excessively difficult in content or in their execution, so that the actor does not feel incompetent or insecure. Also, they must raise positive expectations in the learning evaluation (Blumenfeld, et al., 1991). The design and implementation of this type of activities, obviously focused on intrinsic motivational aspects (Elliot & Mc Gregor 2001; Ryan & Deci, 1989, 2000, Wardani et al., 2020), appears to be a priority task in teaching practice. Moreover, if these activities are properly prepared by teachers who are motivated and involved, they will undoubtedly become attractive and effective (Meyer & Turner 2002).

Drawn from the premise that the main processes developed in a science classroom are based on language and social relationships, it can affirmed that students' interest can make them easier to speak about science (Kelly, 2007), mainly if teachers foster it with inquiry based activities and contextualization (STS), (Jiménez-Aleixandre, 2010). In the last few years, it has been observed that the science class activities that develop the reasoning competence are clearly recommendable for achieving the pursued literacy on scientific competence (Erduran & Jiménez-Aleixandre, 2007; Bricker & Bell, 2008, Zulkipli et al., 2020).

On the other hand, inquiry-based learning can help enhancing students' interest in science, encouraging them to talk about science, and consequently improving their science-learning process (Rocard et al., 2007; Ellwood & Abrams, 2018, Yulianti et al., 2020). An extensive review of the literature related to inquiry based learning, bring together the different points of view on research in the STEM context (Pedaste et al., 2015). In it, the authors develop a cyclical inquiry model structured with phases and sub-phases that meets the essential characteristics this type of learning should have. These phases are: 1- Orientation, 2- Conceptualization, 3- Investigation, 4- Conclusion and 5- Discussion. Also, some phases can be subdivided into sub-phases. Thus, the conceptualization phase can be subdivided in questioning and hypothesis generation; Investigation into Exploration or experimentation which in turn lead to the Data Interpretation; and the Discussion phase can be split into Communication and Reflection. In a resembling way, the NSC, define the five essential IBSE characteristics (National Research Council, 2000): scientific questions are asked, evidences have priority, evidence-based explanations are formulated, the explanations are communicated, and so, they are evaluated according to scientific arguments.

Besides, the use of argumentation activities in science classrooms (and in mathematics as well, Zhou, Liu, & Liu, 2021, but less frequently, Kartika, Budiarto & Fuad, 2021) can promote the spirit of inquiry, develop linguistic skills, foster students conceptual understanding and be helpful in performing interdisciplinary knowledge (Faize, Husain & Nisar, 2017; Lambert, & Bleicher, 2017; Erduran et al., 2019; Archila, Molina, & Truscott de Mejía, 2018) and different strategies has been described to reach this objective (Özdem et al., 2017, Erenler & Cetin, 2019). Based on the aforementioned reasons, the objective of this study is to analyze the consequences observed in students, when using entertaining science activities in the formal scientific subject contexts in secondary schools, following a based inquiry learning methodology and encourage their use in education work to improve students' interest and motivation for science. Different ways of developing inquiry skills have been studied (Cayvaz, Akcay, & Kapici, 2020), but these activities are also commonly used as catalyst of the IBL process (Gibson & Chase, 2002).

Method

Despite the obvious difficulty in measuring attitudes, the more or less boring character of science has been sometimes taken as an attitude indicator (Germann 1988; Piburn & Baker 1993; Franco, Oliva & Bernal, 2012). In order to understand the possible changes in motivation different instruments and analysis techniques were used. The results showed data about the opinions and actions of students as well as those of the teachers.

To develop the research, some inquiry based classroom activities whose core element was entertaining science activities, were designed. A *catalog* of experiments, small demonstrations and games or toys were made. These activities were taken from science books and web sites focused in entertaining and discrepant experiments, and adapted to more formal situations for its use in the classroom. Most of these experiments are repeated with different approaches in all of the mentioned books. Specifically, the following experiments were performed in this research:

"The dancing penny", "What causes the water to rise? II", "The obedient diver", "The lifting paper", "The inverted glass of water", "Will the heavy brick hit your nose?", "The mysteriously rising napkin", "Rolling uphill?", The weighted pipe", "Put the coin in the cup", "The balloon in the bottle", "The tight funnel", "The smoke falling", "Tin cans race", "Magic levitation wand", "Galileo cannon", "Ludion", "The bell on the spoon" (Liem, 1987; Sarquis & Sarquis, 2005; Lozano & Solbes, 2014).

These entertaining activities were regularly used throughout the academic year in different secondary schools and at different levels, particularly the physics and chemistry class of 4th ESO (Compulsory Secondary Education, 15-16 years old) and the technology class of 3th ESO (14-15 years old), including curriculum concepts of mechanics, electrostatics, fluids, changes of state, general properties of matter, etc. Advised by the authors, 32 teachers participated in the specific training courses (see below) and as volunteer researchers. They evaluated the proposal of using the aforementioned activities in different contexts: as an introduction of a topic; as an exercise of identification and resolution of problems, etc.

So as not to extend this study too long, it will only be given one example of these of activities explained, the performance of the *Cartesian diver* or *Cartesian devil*, a classic science experiment, named by René Descartes, which demonstrates the principle of buoyancy (Archimedes' principle) and the ideal gas law (Amir & Subramaniam, 2007; De Luca, & Ganci, 2011; Lozano & Solbes, 2014). The traditional version of the Cartesian diver that students can make consists of a plastic bottle full of water, in which there is an object inside that can sink or float according to the pressure applied to the bottle. The object properly ballasted, placed inside, can be any small container, that can contain air and is open at one end, so that water can go in and out, e.g. an inverted test tube, a pen cover, a Pasteur pipette, a small balloon, etc. (see Figure 1).

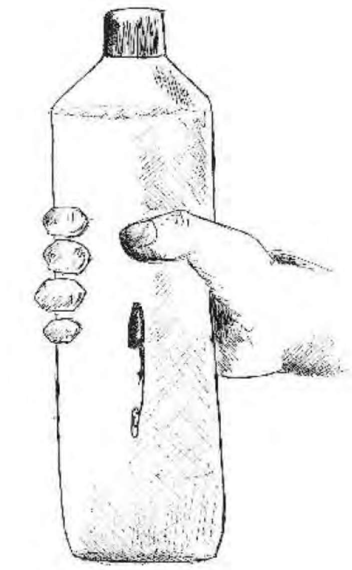

Figure 1. Cartesian Diver or Cartesian Devil

Students are given the questions and activities from the perspective of inquiry based learning, so that they do not only observe the phenomenon and test the teacher's explanation, but also inquire and reflect into the Cartesian diver.

1. *Why does the object sink when exerting pressure on the bottle and then rise when ceasing the pressure?*
2. *What does an object behave in this way and what does it depend on?*
3. *What physical principles are shown by means of the Cartesian diver?*
4. *Can you think of any practical application of this phenomenon?*

Once the activities where developed in the groups participating in the study, some students' questionnaires prepared in the previous analysis (control group), were used to evaluate their opinions about the distinct aspects of the scientific subjects and the diverse methodologies used when teaching them. Additionally, a scrutiny of the quality of the students' inquiry discourse was done in order to verify the degree of students' implication when carrying out these activities. At the same time, a selected group of teachers was taking some courses on how to use these types of activities, and their opinions were also asked for by means of questionnaires. Finally, some semi-structured interviews (Quinn, 2002) were carried out with the teachers that had used these activities in their respective classes.

Students' Questionnaire and Qualitative Analysis of their Responses

An opinion questionnaire was created for the students. It was based on the already validated by Robles et al. (2015) (Table 1). For its final validation (small changes) it was supervised by 12 experts in science teaching and it was rehearsed with a pilot group to observe failures and difficulties in understanding it. Rated from 0 to 10 (the most usual scale in Spanish School environment), it was determined the interest raised in the different activities. The questionnaire included a wide variety of activities and resources used as *distracting* elements, so as not to condition the students. It also included two open questions asking them for proposals in order to improve their interest in scientific-technological subjects. So based on the students' most common answers to the 2 open questions, some qualitative analysis was carried out.

Table 1. Questionnaire Used with Students (3th and 4th ESO)

School: AGE : Grade : 3 ( ) 4 ( ) Gender M ( ) F ( )

1. List the factors that increase or would increase your interest towards science and technology subjects.

a)………………………………………………………………

b)………………………………………………………………

2. Rate (from 0 to 10) your interest in the following scientific and technological activities used: [0=very negative…10=very positive]

Laboratory practices	Workshop's activities	Theory explanations/lectures
Visits to factories, museums…	Use of games and toys	Numerical problems
Educational videos	New commentary	Debates / discussions
Demonstrative experiments	Research projects	Posters production
Use of computer applications	Role-playing (simulation of situations)	

3. Suggest other activities that, from your point of view, would make the scientific and technological subjects more interesting ………………………………………

Participants

It is important to distinguish two parallel actions. In the first phase of the diagnosis, the questionnaire shown above was used to ask the opinion of students of 3th and 4th of Compulsory Secondary Education (14-16 years old). The control group was made up of 170 students of public and private schools, some urban, some rural, from 4 Spanish regions (Andalusia, Balearic Islands, Murcia and Valencia).

In the second phase of intervention, two sub-groups were considered to analyze the difference in students' opinions. The first sub-group only completed the questionnaire at the end of the course, while the second did it both at the beginning and the end. In both cases, all of the students carried out several entertaining science activities throughout the year. The first sub-group includes 65 students from three schools (two of them urban and one rural). These students only answered the questionnaire at the end of the course. The second sub-group was made up of students who completed the questionnaire twice, once at the beginning and once again at the end of the course (pre-post). This group includes two groups of 3th ESO and one group of 4th ESO (total 46 students). Generally speaking, no remarkable differences between the answers given by the different schools were found; either they belonged to the first sub-group or the second one. Consequently, in the section on Results, all answers are grouped.

Analysis of Scientific Inquiry Skills Developed

In this case, for the analysis of the development and improvement in the acquisition of argumentative competences related to inquiry process, some specific sessions with the corresponding students (3th and 4th ESO) were held. The sessions consisted of the presentation of some entertaining science experiments and a request for an explanation related to the astonishing effects observed. These activities were recorded on film and the students' interventions and comments were noted.

Later, these transcriptions were analyzed under the proposals of Erduran, Simon & Osborne (2004), based on the thesis by Toulmin (1958). The clustering method was the methodology used. It consists of analyzing the discourse by identifying the components connected by the correct logical relations. The 7 identified components were:

1. Data (D), evidences or facts that serve as the basis for the justification.
2. Justification or main reason (J), considering the rule or principle that allows the progress from data to conclusion.
3. Reasons or arguments (R), there are different types such as those who show advantages, disadvantages, comparisons or exemplifications.
4. Foundation (F), basic theoretical knowledge which ensures or supports the justification or other reasons.
5. Refutation (Ref), reasons which question the validity of some part of the argumentation.
6. Validity or exceptional conditions (V), they are restrictions or limits on the scope of application of the argumentation.
7. Conclusion (C), statements or assertions whose validity it is supposed to be demonstrated.

This method allows us to qualify the argument according to the diversity of components used. As said by Toulmin, an argument must have at least data, justification and a conclusion (DJC, 3rd order). According to the previous categories, the most complete argument will have seven different components.

Analysis of Scientific Inquiry Skills Developed

Teachers attended courses on the application of entertaining science activities in the classroom. The courses were organized by a regional Teacher Training Center (CEFIRE). The 32 participants answered to a short and specific questionnaire (see Table 2), of only three questions with Likert type of answers without a value tendency, in which they were asked their opinion about the increase of motivation, interest and the improvement in the students learning when using these techniques.

Table 2. Questionnaire Answered by Teachers who had attended a Specific Training Course

Use of "entertaining" elements:	Absolutely agree	Agree	Disagree	Absolutely disagree
It improves the motivation of students				
It increases the students' interest in the subject				
Favours the learning of theoretical concepts				

In addition, they were asked the following YES/NO question: "Do you think the entertaining science activities should be part of the usual teaching practice". Finally, semi-structured interviews (Quinn, 2002) were made with the teachers participating in the research. Some of the questions used to invigorate the interview were:

> "*Have you used entertaining activities before? Do you think that these types of activities increase the students' motivation and interest in scientific subjects? Do you think that, in general, the use of entertaining experiments through an inquiry based approach improves students' learning?*"

Results and Discussion

Students' Results

The values obtained from the students' questionnaires were compared in order to observe any possible significant changes, paying special attention to those items directly related to the implementation of entertaining activities (use of games, toys, experiences with unexpected results, etc.). The statistical study was carried out using the program SPSS (IBM, SPSS Statistics), and the first discovery was that the data did not respond to a normal distribution (Kolmogorov-Smirnof). Consequently, some U tests (Mann-Whitney) were applied to non-paired samples and the W test (Wilcoxon) to paired samples for non-parametric statistics in the comparison of groups. On the other hand, the open questions of the questionnaire, that requested proposals to increase the students' interest in scientific subjects, were counted by grouping them in different categories. The results of the questions related to entertaining science, shown by the different groups, were compared.

Comparison between Control Group and the Group after Intervention (Treated Group)

Given that they are non-paired groups, Mann-Whitney tests are applied (see Table 3).

Table 3. Analysis of the First Sub-Group (Treated Group - Control Group)

ACTIVITIES	-average values- After intervention (N = 65)	-average values- Control group (N = 170)	***p*** (bl.) Asymp. Sign. (M-W)
Laboratory practices	8.60	7.39	*0.001**
Workshop's activities	7.14	7.20	0.747
Theory explanations	4.95	4.27	0.145
Visits to factories…	7.14	6.78	0.664
Use of games and toys	8.12	5.89	*0.000**
Numerical problems	4.75	3.90	*0.046**
Videos	6.55	5.61	*0.019**
News commentary	5.80	5.35	0.344
Debates / discussions	6.92	6.42	0.443
Demonstrative experiments	8.05	6.56	*0.000**
Research projects	6.88	6.29	0.276
Posters production	5.78	5.59	0.539
Use of computer applications	7.86	8.36	*0.032**
Role-playing	8.45	7.33	*0.003**

*: Values confirming a significant difference between the groups.

As it can be seen, the largest differences occurred in those activities that are the core axis of this study and which can be directly associated to the concept of entertaining science. The *use of games and toys* increases the average 2.23 and the *demonstrative experiments* increase 1.49 with *p (Mann-Whitney) values* of 0.000 in both cases. This means that the probability of these differences being at random is lower than one per thousand.

In agreement with the general approach, the laboratory practices also show very significant values, given that on some occasions the small surprising experiments can be seen as practice. The rest of items do not show very significant differences and, if shown, they are not clear-cut. In Table 3, the values that present significant differences are marked with an asterisk. The reasons behind the differences of the rest of the components go beyond the scope of this study. Nevertheless, it is worth observing that in the following sub-group (see Table 4), after the analysis of the questionnaire, the majority of these differences *wane*.

Another good way of explaining the differences of the values is by observing the changes of their preferences for the various activities. Thus, the order of preference of *toys-games* and the *experiments* go up from the 9th to the 3rd and from the 6th to the 4th respectively. Regarding the two open questions (1st and 3rd in Table 1) it is necessary to categorize the answers. The categories are *demonstrative experiments*, and *laboratory practices*. The reason being is that the last ones are focused on the verification of certain laws by means of data collection, quantitative analysis of the results, etc., whereas the first ones have a more qualitative character.

After the overall count, it can be observed that the percentage of proposals related to *demonstrative experiments, etc.* rise from 3.98 % obtained in the previous analysis to 17.38% in the total of the responses. Something similar happens with the concept of more fun or less boring, relating to the science classes, which increased from 6.69% to 14.47%. Both differences are quite significant and directly related to the object of our study. Moreover, both show students' preference for entertaining activities to improve their interest and motivation in science lessons.

Comparison between the Answers pre and Post Intervention

For the analysis of this group the results obtained at the beginning and the end of the intervention were compared, as shown in Table 4. There is no doubt that the most significant finding in this sub-group is the excellent assessment given of *toys* and *games* in the questionnaire filled in at the end of the course (post). This shows a difference of +2.54 points compared to the analysis at the beginning and of +2.76 compared to the data obtained in the control group (p=0.000 in both cases).

Table 4. Analysis to the Second Sub-Group, Pre-Post (N = 46)

ACTIVITIES	average values		P (bl.) Asymp.
	Course Start (pre)	Course End (post)	Sign. *(Wilcoxon)*
Laboratory practices	7.98	8.85	0.001*
Workshop's activities	7.50	7.41	0.885
Theory explanations	5.20	5.22	0.936
Visits to factories…	7.02	7.17	0.277
Use of games and toys	6.11	8.65	0.000*
Numerical problems	4.96	5.02	0.680
Videos	5.85	6.57	0.037*
News commentary	5.87	6.17	0.072
Debates / discussions	7.11	6.85	0.439
Demonstrative experiments	6.67	8.30	0.000*
Research projects	7.02	7.11	0.733
Posters' production	5.61	5.72	0.294
Use of computer applications	7.72	7.63	0.669
Role-playing	8.07	8.70	0.008*

Similarly, the *demonstrative experiments* are also very positively assessed after the use of a methodology that includes entertaining science activities (frequently understood as *experiments*, and often included as small *demonstrative experiments*). It is worth mentioning that in the control group questionnaire the question "what is the use of *toys and games*?" appeared several times. This gives us an idea of the scarce use of this type of activities. Consequently, in the key items it can be seen an increase of 1.63 throughout the year and of 1.74 compared to the previous analysis (also, likewise, p=0.000). When the answers were put in order according to their valuation, the use of games and toys rose up to the 3rd highest rated position (9th at the beginning) and the experiments up to 4th position (8th at the beginning).

As of the rest of the items, the laboratory practices improve again substantially due to the reasons stated in the previous sub-group, whereas the rest are more or less the same at the beginning as of at the end of the year (except for the videos and the role-playing, whose general improvement responds to reasons that are out the scope of this study). Regarding the answers to the open questions, the demonstrative experiments account for 4.85% of the proposals at the beginning and 16.47% at the end (as stated above, it was 3.98% in the previous analysis of their comments). Probably the most remarkable and most consistent thing of this implicit hypothesis of this study is the fact that at the beginning there were only a 2.21% of comments related to make the science classes *more fun-less boring* and at the end 15.98% of the proposals were connected to this (6.69% in the previous study).

Analysis of Argumentative Elements used in the Inquiry Process

The analysis of the inquiry-argumentative skills developed according to the established parameters showed high levels of argumentative quality. Nearly all Toulmin's argumentative elements, justification, reasons, arguments, implementation of new data, validity and restrictions in their application, refutations and conclusions were present in all trials. Figure 2 shows a flow chart including the main elements present in one of the groups when requesting them to explain the functioning of the *Cartesian diver* or *Cartesian devil*.

The flow chart (see Figure 2) shows in a schematically way the main argumentative elements that were taken from the analysis of the transcription of the conversations that took place in one of the small work groups. It is clearly shown that the main elements of inquiry process, data, justification and conclusions, as well as higher level elements, such as validity, refutations, reasons, etc., were all present (MR, NR, FL, etc. are pseudonymous of the students names).

In the classroom, when the different groups carried out the proposed activity, for technical reasons, it was decided to register only one group that was chosen randomly in each activity. The stated elements together with others that are not included here, such as the dynamism and non-verbal language confirm that the activity was clearly interesting and motivating for the students. As a good example, it is worth mentioning the sentence uttered by MR, who, after some group discussions and at a moment of highest concentration in order to solve the proposed question, he raised his head while smiling and said: "teacher: you put us on tenterhooks", which shows a clear involvement in the activity and interest in solving the problem. Every experience recorded in the groups involved showed very similar results. All the main argumentative elements and a high number of secondary ones were present in their experiences, reaching sometimes level VII.

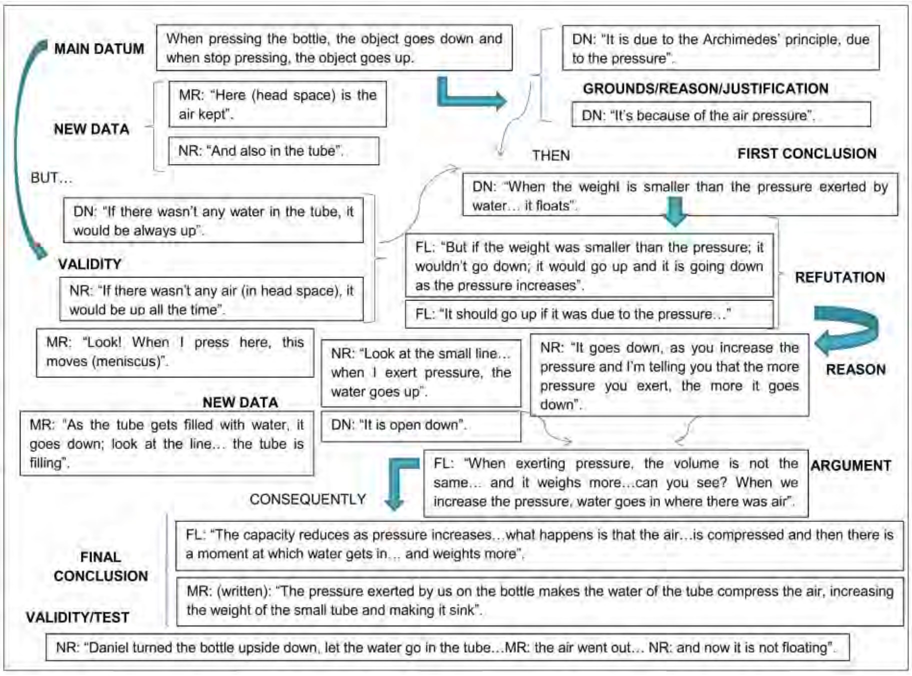

Figure 2. Flow Chart Showing the Argumentative Elements Found in the Experience of Interpreting the Cartesian Diver

Teachers' Results

Analysis of the answers obtained from the questionnaire responded to by the teachers who attended a specific training course for assessing and evaluate the proposal. The question "*Do you think the entertaining science activities should be part of the usual teaching practice?*" was answered with yes in 100 % of the cases. The results of the Likert type questionnaire answered by the teachers are shown in Table 5.

Table 5. Total and Percentage Counting of the Teachers' Answers to the Questionnaire (N=32)

Use of "entertaining" elements:	Absolutely agree	Agree	Disagree	Absolutely disagree
It improves the motivation of students	32 (100%)	0	0	0
It increases the students' interest in the subject	25 (78%)	7 (22%)	0	0
Favours the learning of theoretical concepts	19 (59%)	13 (41%)	0	0

The results are clear. By a majority, the teachers who attended specific training on the use of entertaining science activities as inquiry based learning, understood as a teaching practice that takes into account the scientific-technological subjects, absolutely agree on the fact that their use improves students' motivation, increase their interest in the subject and favor the learning of the theory concepts. As for the order of their preference, first, it increases students' motivation, second it increases their interest, and third, it favors the learning of theory concepts. As confirmed by the percentages, in view of the unanimity, it can be stated that teachers think that the use of entertaining science activities improves students' motivation, to a lesser extent the interest and smaller but still significant, favors the learning of theory concepts.

Teachers' Answers to the Semi-Structured Interviews

The teachers who attended the above mentioned specific training courses were selected for the interviews. As an example, it can be chosen some answers from teachers who used entertaining science activities (participants in this study) and who had not done it before. The main reasons given not to use them, before the training courses, were the lack of time and materials.

However, entertaining science activities, as the teachers experienced when taking the training, do not require a long time and their preparation and development are simple. Also, the materials needed are very accessible and the majority of them can be completely developed in a conventional classroom. Consequently, many of the teachers who attended the training course have used them, including those whose pupils answered the questionnaire. Here are some of their revealing statements:

> T3: "*I thought that this type of activity required a lot of time...and that the students would waste a lot of time doing this activity but, on the contrary!... they were much more concentrated than in our normal lessons…*"
>
> T2: "*Even though I knew many of these curious experiments, I did not often use them in my classes... I have realized that those "small toys" help a lot in putting new energy in the class…*"
>
> T5: "*At the beginning I thought it was going to be a pain in the neck carrying everything to the classroom, also that I should not take any material out of the laboratory... In the end, most of the times, a small tray was more than enough to carry all the material for the whole class.*"

Regarding students' motivation and interest in entertaining science activities, they said:

> T2: "*Their interest could not have been greater…. They were asking for it permanently… these activities are very enjoyable, very practical and students like them a lot.*"
>
> T4: "T*hey were really interested. The days, on which there were not any experiments in class, they missed it a lot… ( ) …Moreover, after having done these activities in class, they developed them again to show their parents and their friends (...). And the students without any help came to their own conclusions.*"
>
> T1: "*They really enjoyed themselves … When you offer something that they can manipulate, and it has a result, it is the best. I mean, experimenting, getting a result…has an immediate impact, in the short run. When you do that, you are going to succeed for sure.*"
>
> T3: "*Yes, certainly. It is clearly motivating and I will tell you why. Because, for instance, when they are studying in the forthcoming years… they will remember the experiments they have done …*"

Even though these teachers did not use entertaining activities before, after having used them, they consider that these types of activities increase the motivation and interest of students in scientific matters. Likewise, they consider that in general their learning increases with the use of entertaining activities. They point out:

> T1: "*The students understand better this way; and the concepts… the complex concepts, forces or whatever it is, are experienced by them. They are playing and the concept then deepens more easily and then the objective is met, of course.*"

T2: "*They understand better the concepts and the scientific procedures…They clearly see them*"

T4: "*They love touching everything. Concepts like pressure, or... whatever, are interesting for them as far as they can touch and, the more fun, the better…*"

Conclusions

In light of the results shown in the Tables and graphs, it can be concluded that:

• The assessment that students do about the entertaining science activities (use of games and toys and the realization of small demonstrative experiments) compared to other types of activities (commonly used in the classroom of any subject, and use as distractors) show significant improvements when these activities are frequently used in class by teachers trained on their use. This proves their potential as a means of improving the students' attitude and interest towards the learning of science.

• When answering the open questionnaire about the kind of activities that could improve their interest in science lessons, students used to carrying out entertaining science activities portray a significant change in their preferences. It can be observed an increase of 12 to 14 percentage points in the categories related to this research work like games and toys and short demonstrative experiments.

• In the analyses of the recorded sessions, it has been found the presence of Toulmin's three basic elements of argumentation related to inquiry process, data, justifications and conclusions as well as a considerable number of secondary argumentative elements that verify the hypothesis set in this study and which can be explained by the inquiry and motivating entertaining activities.

• The teachers that underwent the specific training unanimously consider advantageous the implementation of entertaining science activities as usual activities in class. Likewise, the sample's teachers think that the use of these methodologies improves students' motivation. A substantial part of them also support the idea that these activities increase interest and improve learning.

• In the semi-structured interviews carried out after the research, the participating teachers say that the realization of these types of activities is very positive in the process of teaching-learning of scientific matters and also contributes to an improvement of the students' attitude and interest towards science.

Ultimately, it can be observed that the use of these types of activities in class involves an improvement of students' motivation, changing their negative perspective in some aspects (tedium or boredom) usually associated to scientific subjects. On the other hand, the results show that entertaining science activities favours students' conversations about science favoring inquiry based methodologies and, particularly enhancing the fact that they can argue scientifically. In addition, according to the interviews, it could be said that the implementation of these methodologies in the early stages of the educational process could be even more motivating than in secondary education, which could be considered as a starting point for further investigations.

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