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School Science Conference to Develop Critical Thinking Skills

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Abstract

Critical thinking is a complex construct to address in the classroom. Communication, or the transmission of decisions made using scientific language appropriate to the context and intentions, is one dimension that makes it up. Activities where students participate by playing other roles are suitable for developing communication. In this research, we present an activity analysis with 15 grade-10 students (15-16 years) from a high school in Málaga (Spain) who acted out a science conference in their school. They pretended to be research scientists in inorganic chemistry. To do so, they first conducted an experimentation session about chemistry and collected data, and then they wrote their papers on a template provided by the congress. The teacher acted as a reviewer of the papers. Finally, the conference was held with the oral papers. Teacher's assessments of oral communications and an activity evaluation survey were used as data collection instruments. The oral presentations improved compared to previous activities since students incorporated more technicality in their speeches and used a more scientific, comprehensive and precise vocabulary than on previous occasions. The students rated this activity with an average of 9 points out of 10. They considered that their learning had improved 3 points out of 10 (from 6 to 9 points between before and after the activity), and they rated it as a quite interesting, useful, attractive and simple activity. School science conferences can be a motivating experience to develop communication skills and develop students' critical thinking.

Keywords: *Critical thinking, School science congress, Communication skills, Chemistry education, High school*

1. Introduction

Critical thinking is a complex construct to address in the classroom, and in the case of science education, communication is an important skill that integrates it. Communication means transmitting decisions using scientific language appropriate to the context and intentions [1].

The communication of knowledge is a fundamental part of the scientific process, as it allows the advances made in science to be disseminated and favours the development of critical thinking among citizens, an element that contributes to scientific literacy, which is so necessary today. On the other hand, the communication and dissemination of scientific knowledge derived from the projects carried out contribute to the social recognition of the students' work.

Science communication can be worked on in the science classroom through different strategies. Some of them are role-playing games, educational fairs or science conferences.

Role-playing games or simulations where students participate by representing a character favour communication skills by promoting scientific argumentation and the oral expression of ideas [2], [3]. In addition, this type of activity also contributes to the acquisition of the scientific learning on which the activity is based [4], [5].

Science fairs are a format that emerged in the 1950s in the USA, where high school students showcased their scientific work to explain a complex concept [6]. They are events where students can show their "merchandise" - in this case, science - to the public.

Another interesting activity is the simulation of scientific conferences where the student adopts the role of a researcher presenting a research that he/she has previously carried out in the lab. The simulation

of a scientific conference is a useful educational strategy in the acquisition of scientific competences and skills. Among them are correctly presenting the results of a research, knowing how to conclude what is important in such a topic, learning to express information in some format such as a scientific poster, synthesising the whole study and transmitting, explaining and defending the information obtained. This communication offers the opportunity to present studies, projects or experiences clearly and concisely, with the necessary information where the author can develop their creativity and express it permanently [7].

This paper proposes an activity based on a School Science Conference to develop communication skills in secondary school chemistry students and presents students' ratings and perceptions of the activity.

2. Methodology

This study was conducted with 15 Spanish grade-10 (15-16 years) students taking a chemistry subject from a high school in Malaga (Spain). The students received instruction on the research topic related to the conference, namely chemical substances and types of bonds.

The proposed activity consisted of recreating a School Science Conference at the school where students participated in the role of scientists. This activity was carried out at different times. First, they conducted an experimentation session about chemistry and collected data. Then, in the laboratory, each student built an electrical circuit with a battery, a light bulb and a solution. Then, the teacher handed out different substances: sodium chloride, deionised water, acetone, ethanol, hydrogen peroxide and acetic acid. Finally, the students used the electric circuit to study the conductivity of the assigned substances and had to establish the type of chemical bond each of them had (Figure 1).

Figure 1. Student measuring the conductivity of a solution

Secondly, they wrote their papers on a template provided by the conference. The teacher gave them a template for the conference communication where they had to fill in an introduction about the substances worked on in the laboratory, the methodology followed (where they had to explain the construction of the circuit, the materials used, their use and the experiments carried out), the results obtained in the experiments, the conclusions and the references used. The teacher acted as a reviewer of the papers giving them feedback on those issues that could be improved or needed to meet the quality standards of the research. Finally, the conference was held with the oral papers. The students acted at the conference as scientists presenting their research data to their peers, with a time of ten minutes for their presentation.

The data collection instruments were:

(a) The evaluation of oral presentations by the teacher.

(b) The results obtained by the students included in their papers.

(c) A survey assessing their learning and the activity. Students were asked to score the activity from 0 to 10 points, positive and negative aspects of the activity, perception of their knowledge a score of between 0 and 10 before and after the activity, and four qualities of the activity (simplicity, attractiveness, usefulness and interest) on a Likert scale (nothing, little, quiet, a lot) [8].

(d) A questionnaire on felt emotions. They were asked to choose one of the seven levels, the extremes of which were 10 opposing emotions (afraid-calm, stressed-relaxed, worried-unconcerned, insecure-confident, displeased-happy, suspicious-confident, unhappy-happy, bored-enthusiastic, unsatisfied-satisfied, uninterested-interested) [9].

3. Results

The teacher's evaluation of oral communications revealed that students incorporated more technicality in their speeches and used a more scientific, comprehensive and precise vocabulary than on previous activities. Figure 2 shows the justification of one of the students showing why hydrogen peroxide is not an electrically conductive solution.

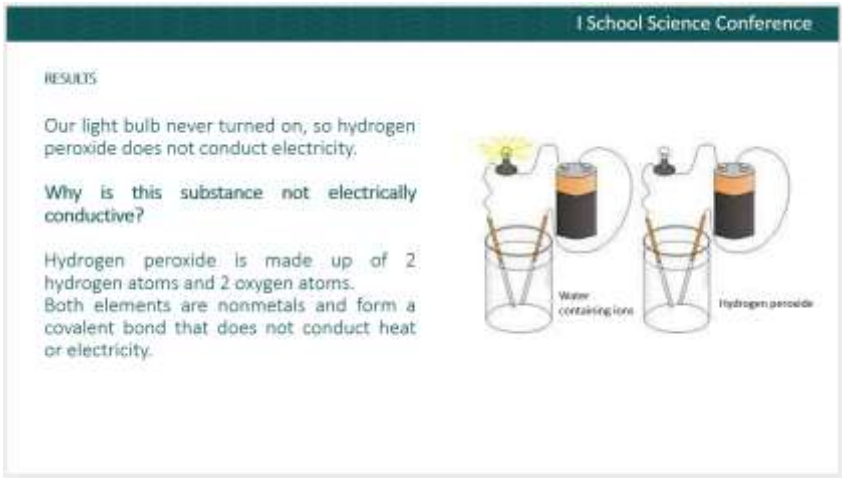

Figure 2. Student presentation during the conference

The students rated the school science conference with an average of 9 points out of 10. In addition, they rated their knowledge before the activity with 6 points on average, and after the activity, they considered that it improved their learning by 3 points out of 10.

100% of the students indicated that the best aspect of the activity was conducting the experiments in the lab. Some of the comments in this respect were, '*The best thing was the class we spent in the lab practising and taking notes on the experiment*'. As for the worst aspects, 45% of the students referred to the limited time to carry out the activity ('*very little time was devoted to the activity, especially to do the communication*'). In addition, 40% said that it was difficult to fulfil all the requirements for the elaboration of the template ('*The most difficult thing was to fill in all the pages of the template with all the formatting details requested*'). 15% indicated the difficulty of building the circuit (*'My circuit did not work and I had to do several tests until the light bulb came on*").

Students rated the activity as useful and interesting, with the qualities simple and attractive receiving lower ratings (Figure 3).

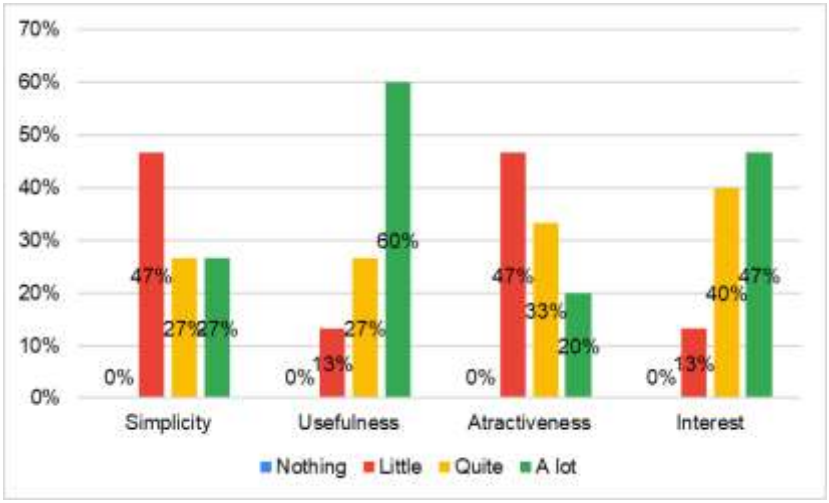

Figure 3. Students' assessment of the qualities of the activity.

The emotions experienced during the activity were valued highly, as all students indicated positive emotions from each pair provided. The emotions unconcerned, happy and satisfied obtained the highest level. These positive emotions experienced suggest that this activity enhanced the motivation and interest of students (Figure 3).

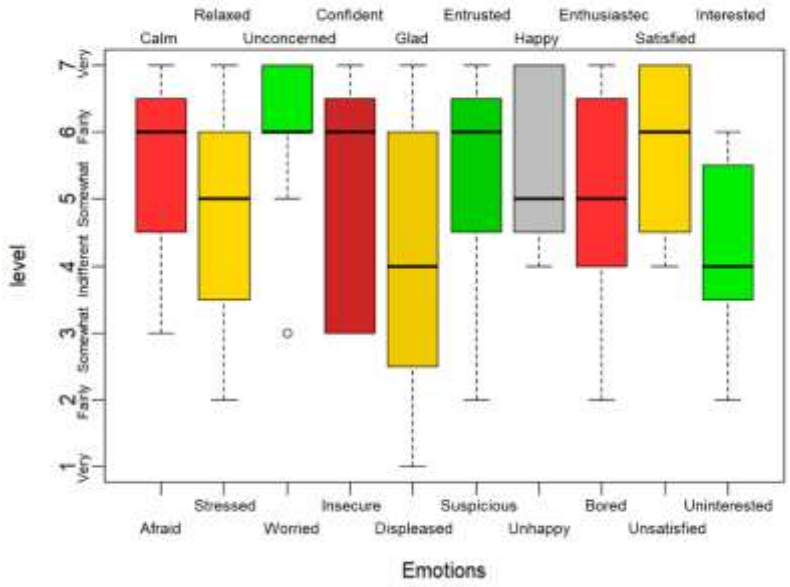

Figure 3. Emotions experienced by students during the activity.

4. Conclusions

The data obtained in this study suggest that students received it well School Science Conference. The students improved their scientific expression by incorporating more technicalities in their speeches and using a more diverse and precise scientific vocabulary, compared to previous presentations, because they were not acting like students. During the conference, they had the role of scientists, so they tried to express themselves as researchers. School Science Conferences can be an experience to develop communication skills, one of the dimensions that make up critical thinking. [1].

Holding a School Science Conference also brings students closer to how scientists work, highlighting the importance of communication as the last stage of scientific methodology, often forgotten in secondary school. In this way, students can appreciate the importance of scientific conferences, what they are for, the benefits and difficulties they present, and the work review processes.

The worst-rated aspects of the activity, such as time and the complexity of the research template, are issues to be improved for future editions. In addition, some students indicated that the worst aspect was the circuit's construction because some needed help making it work properly. These questions made the students give a lower value to simplicity and attractiveness of the activity. On the other hand, the positive emotions experienced indicate that this activity enhanced the motivation and interest of students.

As future lines of work in the classroom, new editions of the School Science Conference will be held with new students and those who participated in this experience to continue improving our students' communication skills. Finally, it is also worth highlighting the importance of this type of activity to awaken students' scientific vocations.

5. Acknowledgements

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