PRESERVICE PRIMARY TEACHERS' REPRESENTATIONS AFTER TEACHING OF THE ELEMENTARY ELECTROSTATIC PHENOMENA

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ABSTRACT

In the present communication, we identify the conceptions after teaching of 120 pre-service elementary teachers on the production of electric charges, the law of attraction between charged objects and between a charged object and an electrically neutral object. To this end, we constructed a multiple choices questionnaire composed of six questions. Each question had been formulated as a statement. To answer each question, pre-service teachers had to indicate if the statement is true or false, while justifying their choice. The analysis of the data of this questionnaire shows that several pre-service teachers succeeded in changing their initial erroneous conceptions after being submitted to a teaching strategy. It also shows that some of their erroneous conceptions persisted after teaching.

Keywords: *Conceptions, electrostatic, after teaching, preservice teachers, elementary school*

The context and purpose of the framework

There is little research that identified the conceptions of elementary pre-service teachers with regard to the electrostatics phenomena (Guruswamy and al. 1997; McMillan Swadner and, 1991; Métioui and Trudel, 2007, 2014). For example, Métioui and Trudel (2014) identified several erroneous conceptions. Some are as follows: (1) the lightning during an electric storm results from the meeting between particles of hot and cold air, (2) the chock that one can receive in touching a metallic handle or touching a person when rubbing one's feet on a carpet on a dry day results from the attraction between two objects, one charged negatively and the other charged positively (a person and a handle or two persons), and (3) the static electricity on a ball being rubbed will make it stick to the wall. Also, there is little research that identified the conceptions of elementary pre-service teachers having followed activities related to the teaching and learning of electrostatics (Criado Garcia-Carmona and, 2010; Guruswamy and al. 1997). In this perspective, the present research has attempted to identify a set of conceptions of Quebec students being educated for teaching at the elementary level. The conceptions are follows: the production of charges (positive and negative), the law of attraction between charged objects and between a charged object and an electrically neutral object. In the curriculum of the Ministry of the education (2001), pupils must be presented with notions related to electrostatics such as follows: (1) describe the effect of electrostatic attraction (ex. paper attracted by a charged object), (2) distinguish the objects that are electrical conductors from those which are electrical insulators, and (3) explain the insulating properties of various substances. These students were taught these topics in two stages. In the first stage, groups of two students did laboratory work spaced out on two periods of 3 hours each. To this end, a set of experiments was set up with simple materials to illustrate the phenomena. During the experimentation, the students had at their disposition a laboratory protocol that served to orient their work, while avoiding a remote-controlled presentation. This protocol consisted of three distinct stages that guided the participants in their interactions with the phenomena. These three stages were respectively the prediction, the observation and the explanation of the phenomenon. In order to incite an interaction between the proposed experiments and the explanatory system of the pre-service teachers about the studied phenomena, the members of every group had to share their

reflections in writing before and after the experimentation, as demanded by the protocol. In the second stage, a return with the whole group was organized under the professor's supervision to exchange on the results of the experimentations. No scientific notion had been presented to them at that time and these students had to refer to their previous knowledge to interpret their observations. This process is contrary to the one that is done in traditional teaching where the laboratory work takes place after having studied the scientific notions. Thus, in this experimentation, these notions were introduced to them after the laboratory experiments. Several supports were used to illustrate them, as for example the viewing of movies in the Web on electrostatic phenomena and relevant readings of documents on the topic and a group discussion in group.

Construction of the questionnaire/Analyses of the data

We constructed a questionnaire paper-pencil of four questions which is presented in the appendix. Every question is elaborated as a multiple choices questionnaire (MCQ) and the students had to justify their choice of answer. The required justification makes it possible to identify the student's conception. Below, the objectives of every question, its analysis and the justification given by students as illustration are presented.

At first, the intention of question #1 was meant to know if the students will be able to deduct, from the distribution of the charges, that the ball is electrically neutral, because it contains 6 positive charges and 6 negatives ones. However, the stick is charged positively, because it is made up of 9 positive charges and 6 negatives ones. Then, they had to deduct that the ball will be attracted by the stick, following the phenomenon of polarization. Indeed, while approaching the neutral ball, the stick will attract its negative charges that will be nearer and repel its positive charges. The global effect of forces will therefore be an attraction. According to 26% (21/79) of the students, the ball will not be attracted or repulsed because the rule: (1) has as many electrons [6-] as the ball [6-], (2) the ball is not charged, (3) there will not be any transmission of electrons since the rule is charged positively or (4) because the ball is not a conductor. For many of these students, their false conception results from a misunderstanding of the electric charge notion [“The rule has 6 electrons that can differentiated by (-), the ball has also 6 electrons (-), therefore it will neither be attracted or repelled since the rule does not have a surplus of electrons.”] For 18% (14/79) of the students, the ball will be repelled, because: (1) as the rule has as many electrons as the ball, they are charged equally, therefore they are going to repel each other and (2) the rule possesses fewer electrons (charged positively). Finally, for 56% (44/79), the neutral ball will be attracted by the rule charged positively, which is correct. Only 27% (21/79) of the students succeeded in explaining correctly the attraction of the ball, referring to the phenomenon of polarization: “According to the law of the opposite charges, the rule (positively charged) attracted the ball (neutral element). Because the reorganization of the charges in the ball will bring closer the negative charges near the rule and the positive charges of these will move back.” The remaining students (29% - 23/79) did not give any justification or gave an incomplete or erroneous justification. In this last case, they explained the attraction by indicating that the rule has a deficit of electrons.

Question #2: The intention of this question was to find out if he students understood well that a charged object can attract an object of contrary charge or an object electrically neutral in accordance with the law of the charges. In the case of the neutral object, its charges are reorganized depending on the charge of the object that is next to it (phenomenon of polarization). 47% (37/79) of students answer affirmatively, that is, if a positively charged rule is near a given object and a repulsion is observed, the latter must be charged with contrary signs. From the data analysed, two categories of answers were identified. They are presented as follows with the justifications advanced as illustrations:

Category 1 (38%-30/79) - Two objects of contrary charges attract, in accordance with the law of the charges. Thus, for these students, the repulsion only occurs between two charged objects,

which is not always the case since it can take place between a charged object and a neutral object (phenomenon of polarization): “To have an attraction, it is necessary that the two objects are of contrary signs. Therefore, if the rule is charged positively, the object in question is necessarily charged negatively.”(E2)

Category 2 (9%-7/79) - Two objects of contrary charges are attracted in such a way that the negatively charged object will give its surplus charges to the one charged positively which is in deficit and this transfer will allow them to establish an equilibrium. This erroneous conception results from a wrong appropriation of the law of the charges: “In accordance with the law, charges of contrary signs are attracted and the charges with the same signs are repelled. The rule has an excess of electrons that are going to move in the other object which has a deficit and will be charged negatively.”(E4)

As for the other students (39%-31/79), the attracted object is not necessarily negatively charged, which is true. Only 24% (19/79) among them advanced a correct justification: “It is true that a negatively charged object would be attracted by a rule positively charged. However, all object electrically neutral, whose mass is not too elevated, can also be attracted by a rule charged negatively. In this case, there would be reorganization of the charges (positive and negative) inside the object, so that the negative charges stand close to the rule (because opposite charges attract) and the positive charges, at the opposite extremity (because identical charges are repelled). This statement is therefore not entirely true.”(E40) 15% (12/79) did not justify their choice or their justification was incomplete: “Because even though the rule is charged positively, the object can be neutral and there will be attraction nevertheless, because its negative charges will be attracted by the rule.”(E45) Finally 14% (11/79) gave an indecipherable answer: “Some objects include the two positive and negative charges regrouped in two distinct places. The attraction with the negatively charged rule is due to the positive charge that the object contains.” (E70)

The question #3 was meant to verify if the students understood the principle of the functioning of an electroscope. According to 32% (25/79), the statement is false, which is true. The analysis of the data shows than only 19% (15/79) gave a correct justification referring to the phenomenon of polarization [“There is no transfer since there is no contact. The strips spread out because the positive charges are organized in the ball, the negative charges in the two strips, which results in the spreading of these.”(E12)] The other 13% (10/79) could not explain the repulsion of the strips, but stated that the stick did not transfer any charge to the ball since they are not in contact, which is correct [“For a transfer of charges to take place, it would have been necessary that the stick touches the ball, but it only came near it.”(E27)] Finally, for 68% (54/79), the two strips are charged negatively, therefore explaining their repulsion, which is true. To justify their charge, they gave an erroneous justification stating that a negatively charge object which is close to a conductor transfer its charges [“The charges are given to the ball wrapped up in aluminum, because it is a conductor. They circulate toward the strips which spread from one another, because they are both charged.”(E7)]

The question #4 was meant to verify the phenomenon of the discharge of an electroscope. While touching the ball covered with aluminum with a finger, it remains positively charged under the influence of the negatively charged rule and only the negative charges of the strips, which are far from this influence, flow toward the ground, through the person's finger. Thus, the electroscope became positive and the strips will not move apart anymore. According to 58% (46/79) of the students, the strips will not be separated anymore which is correct. However, the given justifications are erroneous. The strips will not move apart because the charges of the stick will be transferred from the ball to the finger [“Because the finger is a good conductor. Therefore, there will be a transfer of charges from the stick toward the ball and the ball toward the finger. The strips will not receive any more charges.”] For 25% (20/79) of the students, the two strips will be less spread out because the charges coming from the stick will be distributed between the ball and

the finger ["The aluminium paper will have the charge that had been transferred in (a) decreased since the finger also receives some.", "Because the charge coming from the stick will be smaller in the strips because the finger will keep a little energy coming from the stick."] Finally, according to 17% (13/79) of the students, the strips will remain spread out like in the case of the previous question because no transfer of charges occurs ["As there is no transfer of charge it changes nothing if we touch the ball.", "Because we have no transfer of charges although the human body is a conductor."]

Conclusion and didactic impact

The results of this research demonstrate that very few students succeeded in acquiring the basic indispensable notions to explain the phenomena of attraction and repulsion between charged objects and between electrically neutral and charged objects, in spite of resorting to several didactic supports giving rise to an interaction between the observations done in a laboratory and the underlying scientific notions. On this topic, Criado and Garcia-Carmonas (2010) point out that the acquisition of the notions related to electrostatics by the elementary pre-service teachers requires several interventions and cannot be acquired correctly in a few hours: "One needs to determine not only the best practical approach in the classroom, but also how much periodic and cyclic learning time would be required to produce satisfactory and steady evolution of the students' ideas." (p. 798).

However, in this research the conceptions identified after the experimented strategy reveals, among others, the necessity to insure that the terms used as positive and negative charges, proton, electron, polarization, conductor, isolating, neutral object, charge and discharge of an electroscope are well clarified. Also, the identification of the conceptions after the experimented strategy helps to locate the gaps in teaching as well as the notions on which it would be necessary to spend more time. The table 1 synthesizes the conceptual difficulties that were identified and the conceptions at a scientific level.

Table 1: Summary of pre-service teachers' conceptions and of their corresponding scientifically accepted counterpart

Erroneous conceptions	Scientific conceptions
A conductor can be charged by contact with a charged object.	A conductor can be charged by contact with a charges object, only if it is isolated.
A negatively charged object in contact with another electrically neutral one transmits its charges.	A negatively charged object in contact with another electrically neutral cannot transmit charges if it is an insulator.
An object electrically neutral contains as many negative electrons as positive ones.	An electrically neutral object contains as many positive charges as negative ones. An electron has a negative charge and a proton has a positive charge.
The polarization of the charges of an electrically neutral object can only occur if it is in contact with a charged object.	The polarization of the charges of an electrically neutral object can be produced from a distance.
A positively charged object is attracted by a neutral object, because the charges seek an equilibrium.	A positively charged object attracts another electrically neutral, because the latter reorganizes its charges (polarization).

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Appendix
Paper-pencil questionnaire

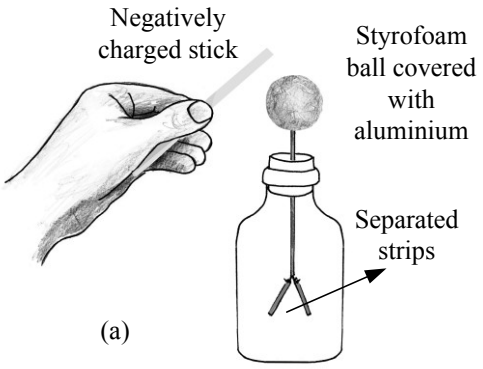
Question 1
If one puts a rule near a ball (without touching), as shown, the ball:
□ will be attracted
□ will be repulsed
□ nor attracted nor repulsed

Your justification.

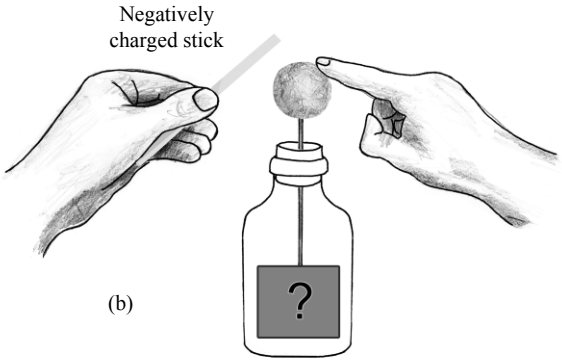
Question 2: If a positively charged rule approaches a given object and that an attraction is observed, it implies that this object is necessarily negatively charged. This statement is:
□True □ False

Justification.

Question 3
When a negatively charged plastic stick is put near a Styrofoam ball covered with aluminum, one observes that the strips spread out as illustrated. Is the following statement true or false? *"The strips spread out because there is a transfer of charges from the stick to the ball."*
True □ False □
Justification.



Question 4
If one touches with a finger the ball while maintaining the stick charges in the previous position, as shown, the strips :
□ Will be less remote than in the precedent case (a)
□ Will remain remote like in the precedent case (a)
□ They won't be separated anymore



Justification.