THE INFLUENCE OF GESTURES IN THE LEARNING OF PHYSICS

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ABSTRACT: Several researches show that gestures are a fundamental element for the understanding of the discourse or of a thought. Thus, when considering the school context, in the communication between the teacher and the student, it is important to understand better the role of gestures in learning. This way, in order to investigate the role of gestures in the understanding of basic Physics concepts, students from the middle and upper classes watched videos with linear momentum contents. The students in each teaching segment were randomly allocated into two groups: one watched the videos where the teacher's gestural activities were shown and the other watched the videos with only the teacher's face. The results show that there was an improvement in the learning of the students who watched the videos with gestures, but this effect was observed only in high school students.

KEY WORDS: gestures, scientific concepts, learning.

OBJECTIVES: The goal of this research is to investigate the role of gestures in the learning of scientific concepts in two distinct periods of formation: high school and higher education.

THEORICAL FRAMEWORK

Gestures, a fundamental component in interpersonal communication, are present in the creation of human language meaning (Chue, Lee, & Tan, 2015; Scherr, 2004). Researches in anthropology and cognitive psychology show that gestural activities are omnipresent, so that in all cultures gestures arise when someone speaks (Enfield, 2005). Even individuals with congenital blindness perform gestures when speaking (Iverson & Goldin-Meadow, 1998), which reveals their importance in language and communication construction.

There are different theories about the function and genesis of gestures. In general, it is a consensus that they help in the production of language and the structuring of thought. This seems to occur because gestures convey meanings, using a representation format other than speech. Thus, more global meanings are "packaged" in this mode of visuo-spatial information in a way that is totally in accordance with spoken language, contributing to the cognitive organization of the speaker and the listener (Kita, 2000).

The production of gestures is also thought of as a simulated action, allowing both actions and perceptual states to be experienced by the speaker. Evidence from neuroscience research reveals that these simulations activate areas of the motor cortex, which is responsible for the production of motions. This means that when talking about the clash between two billiard balls, the dialogue participants form a mental simulation of the scene that includes both the action and its perceptual components (Hostetter & Alibali, 2008, 2010). Thus, several studies show that talking involves simulations and gestures appear as a natural consequence of this process.

In this context, the number of researches that investigate the role of gestures in education (Chue et al., 2015) and mainly, in the learning of scientific concepts, has increased considerably. In a recent quantitative meta-analysis it has been revealed that gestures greatly assist the understanding in listeners and organizes the speech of the speaker (Hostetter, 2011).

According to Scherr (2008), gestures play an important role in the understanding of a speech or thought. Depending on how they are performed, gestures may be a mental notion of the idea, information, or phenomenon the speaker refers to. In a simple conversation, for example, the movement of the hands often accompanies what is said. In addition, many of the gestures used during a dialogue may represent some action or object present at the moment of speech (Scherr, 2004, 2008). Gestures on topics involving movement have produced a greater understanding in the listeners when compared to speeches detached from gestures (Sueyoshi & Hardison, 2005).

In addition, research points to the gesture as a facilitator of thought. In particular for the area of mathematics, an investigation conducted by researchers at the University of Chicago states that the gesture reduces the speaker's cognitive resource demand and frees cognitive ability to perform other tasks such as memorization (Goldin-Meadow, Nusbaum, Kelly, & Cook, 2001).

When considering the teaching of science, it is necessary to emphasize that gestures are deeply integrated to the systems of spatial reference, which is of fundamental importance for the understanding of scientific contents (Newcombe, 2010; Wai, Lubinski, & Benbow, 2009). In physics, a survey conducted in different countries shows that physicists have observed the understanding of specific subjects in the area through gesture (Roth & Lawless, 2002). Kontra, Lyons, Fischer, & Beilock (2015) argue that experimentation and use of the motor area of the body are extremely important for the learning of scientific concepts.

Still, there is little research on the role of gestures in learning science content, especially physics. However,

> Research on gesture analysis includes much to interest physics education researchers. Some of the research is potentially of immediate use in diagnosing student thinking, assisting physics education researchers in identifying not only the content of student ideas, but also their source, their novelty to the speaker, and whether the speaker is actively engaged in constructing the ideas. Other research has pedagogical and theoretical implications for our understanding of how learning occurs, offering, for example, an account of how speakers use gesture to reduce cognitive load, or how gesture may assist with organizing information. Physics education is a rich field for exploring these issues further, and physics education researchers may both benefit from and contribute to continuing investigations of the significance of gesture in thinking and learning. (Scherr, 2008, p.12).

Thus, this work contributes to fill the gap by investigating the influence of gestures in the learning of physics concepts in two distinct periods of formation: high education and higher education.

METHODOLOGY

Participants

From this investigation, 98 subjects participated. Of these, 22 are high school students from a private school in the state of São Paulo, which we will call High School Students 1 (HS1); 35 are also high school students, but from a private school in the state of Minas Gerais, which we will call High School Students 2 (HS2); 20 are students of the first semester of the science course in a public university in the state of São Paulo, which we will call Students 1 (S1), and finally, 21 university students, from the same course, of a public university in the state of Minas Gerais, and we will call them Students 2 (S2).

Research development

Three videos were created in which a teacher explains some concepts of Basic Physics. The first video addresses the issue of conservation of momentum, the second inelastic collisions and, finally, the third, elastic collisions. In each of the videos, which have an average duration of 3 minutes, the teacher gives a brief explanation of the concept and then offers some examples related to the theme.

From this video, in which the teacher was filmed from the waist up and the gestural activities were shown, only his face was cut out and from this, another category of videos were created, now, without any gestural activity, but maintaining all the content of the original video. The image below shows a frame of each type of video.

Fig. 1. Frame of the two types of video - first with gestures and second without gestures

Students in each teaching segment, high and higher education, were randomly assigned to two groups: With Gestures and Without Gestures. In order to identify the influence of the gestures in the understanding of the content of the videos, two evaluations were applied, consisting of questions of multiple choices taken from textbooks widely used in Brazil, before and after the presentation. A sample question used in the pretest is shown below (Figure 2). Each evaluation had separate questions, even though they covered the same topics so there was no test effect.

A particle moves with uniform speed v over a straight line and collides unidimensionally with another identical particle, initially at rest. Considering the elastic shock and neglecting friction, we can affirm that after the shock:

a. Both particles move in the same direction with speeds equal to $\frac{v}{2}$;

b. Both particles move in opposite directions with speeds $-v$ and $+v$;

c. The incident particle reverses the direction of its motion, while the other remains at rest;

d. The incident particle is at rest and the other moves with speed v;

e. Both particles move in opposite directions with speed $-v$ e $2v$.

Fig. 2. Sample of question used on pretest

RESULTS

For HS1 (private school students in the state of São Paulo), a Mann-Whitney test revealed that there was a statistically significant difference between the two evaluations (V = 0, p-value = 0.003957) performed by the With Gestures group. However, the Mann-Whitney test revealed that there was no statistically significant difference between the evaluations (V = 0, p-value = 0.01313) for the Without Gestures group.

For HS2 (private school students in the state of Minas Gerais) we performed a t-test for the group With Gestures that revealed a statistically significant difference between the evaluations (t = -8.3039, df = 17, p-value = 07). On the other hand, a Mann-Whitney test revealed that there was no statistically significant difference between the evaluations in the Without Gestures group (V = 12, p-value = 0.221).

For S1 (students from a public university in the state of São Paulo), a t-test revealed that there was no statistically significant difference between the evaluations of both groups (With Gestures: t = -0.9783, df = 10, p-value = 0.351; Without Gestures: t = -1.4744, df = 8, p-value = 0.0893). However, mean scores increased in both groups.

Finally, for group 4 (public university students in the state of Minas Gerais) a Mann-Whitney test revealed that there was no statistically significant difference between the evaluations of the With Gestures group (V = 16, p-value = 0.797). And a t-test revealed that there was also no statistically significant difference between the assessments for the No Gesture group (t = -1, df = 9, p-value = 0.3434).

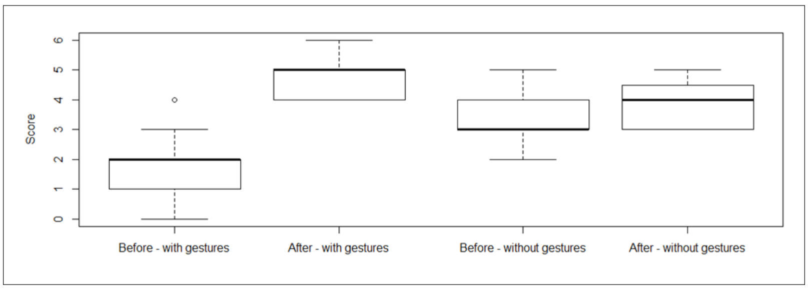

Fig. 3. Boxplot 1 - Test performed before and after HS1 groups

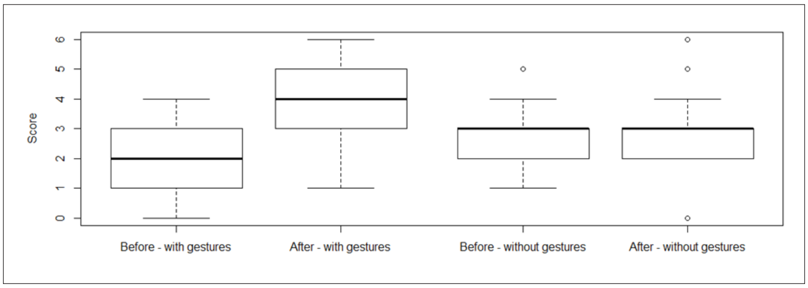

Fig. 4. Boxplot 2 - Test performed before and after HS2 groups

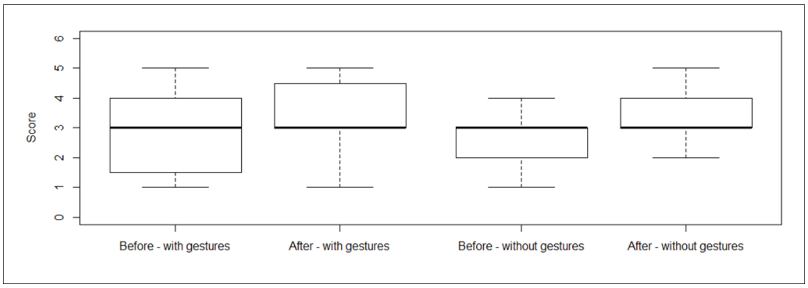

Fig. 5. Boxplot 3 - Test performed before and after S1 groups

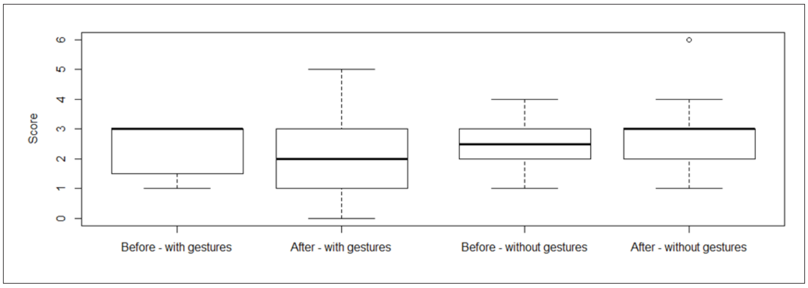

Fig. 6. Boxplot 4 - Test performed before and after S2 groups

In summary, the data obtained allowed us to infer that the high school students who watched the videos with gestural activities presented a significantly greater performance in the evaluation made after the videos presentation. The students who attended the videos without gestural activities, whether they were high school or superior, did not present any improvement in the evaluation.

CONCLUSION

The results indicate an improvement in the performance of only students in the With Gestures group, evidence consistent with the results pointed out in the literature. It is noteworthy that the students belong to two completely different Brazilian states, with very different socio-economic conditions.

However, the effect of the gesture on the students' understanding occurred only with high school students, so that the teacher's gestural activities did not influence the performance of the students of higher education. A possible hypothesis for the interpretation of this result, which escapes the one found in the literature, is that the effect of the gestures can be diminished in the students of higher education since they have already had some contact with these scientific concepts in high school. Further subsequent research is needed to validate this interpretation.

This research shows how the role of gestures should be better understood and researched in science teaching, so that researchers and teachers can consider them in a more systematic and determinant way in their work. It is necessary that more research is conducted on this topic so that the impact of the gestures in the teaching and learning process is fully understood.

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