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# THE ROLE OF EXPLICIT INSTRUCTION OF CONTROL OF VARIABLES STRATEGY IN PRE-SERVICE EARLY-CHILDHOOD TEACHERS' PREPARATION

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*In this study, we aim to investigate if the explicit instruction of aspects of the Control of Variables Strategy within the frame of a pre-service early childhood teacher's science course is crucial in understanding the method. The study is part of a broader project investigating teachers' beliefs and practices on inquiry-based teaching. It was conducted within a university laboratory-type and inquiry-based science course that lasted five units of two hours each. The participants comprised eighty-five second-year early childhood student teachers. The student teachers were randomly divided into two groups, control (N = 40) and experimental (N = 45). The control group participated in several guided inquiry-based experiments without any explicit teaching of the CVS method. Contrary, the experimental group's student teachers not only participated in the inquiry-based investigations but were also explicitly taught the reasoning of the CVS method. Data were collected using a questionnaire. The results showed that the experimental group's student teachers benefited more from the science course. Besides, in the experimental group, the contribution of being able to discern a fair experiment from unfair ones to understand a fair experiment's design was statistically significant only just after the implementation. Teaching implications are also discussed.*

*Keywords*: Inquiry-based teaching, Initial Teacher Education, Science Education

## INTRODUCTION

Current guidelines for effective and innovative instruction in science education suggest teaching with and about aspects of the inquiry procedure scientists follow in their scientific practices (NGSS 2013). Besides, early childhood teacher preparation seems to benefit from pedagogical approaches that include inquiry-based field experiences, aiming to understand inquiry processes (Linn and Jacobs 2015). Thus, careful consideration should be given to early childhood teachers' preparation to use scientific practices effectively in their teaching (Han, Blank, and Berson 2017).

One of the essential scientific practices is the Control of Variables Strategy (CVS), a method for designing and implementing fair experiments to test a variable's influence on a phenomenon (Boudreaux et al. 2008; Chen and Klahr 1999). In particular, a fair experiment comprises at least two tests that should only differ in the tested variable's value while all other variables should be controlled. For instance, to investigate the influence of a magnet's size on magnetic phenomena, the only variable that should be changed between the two tests would be the magnet's size. In contrast, all other variables should be controlled. There is evidence that explicit teaching of the CVS method's experimentation reasoning is necessary for a holistic understanding of the method (Authors 2017; Lorch et al. 2010; Schwichow et al. 2016). In this paper, we present a study that intended to investigate the importance of explicit instruction of the CVS method's reasoning in its understanding in the frame of pre-service early childhood teachers' preparation.

## METHOD

### Participants and description of the teaching environment

The study is part of a broader project investigating teachers' beliefs and practices on inquiry-based teaching. It was conducted within a university laboratory-type and inquiry-based science course that lasted five units of two hours each. The inquiry-based classroom experiments included in this study were realized during two of the five science course units. The experiments concerned phenomena that are usually taught in early childhood education, i.e., floating–sinking (FS) and magnets, investigating, among other issues, the variables that could influence these phenomena. The participants comprised eighty-five second-year early childhood student teachers. The student teachers were randomly divided into two groups, control (N = 40) and experimental (N = 45). The control group's student teachers participated in several guided inquiry-based experiments without explicit CVS method teaching. Contrary, the experimental group's student teachers not only participated in the inquiry-based experiments but were also explicitly taught the reasoning of the CVS method.

Moreover, they had the opportunity to negotiate both fair and unfair experiments to understand their differences. For example, they were prompted not only to distinguish a fair experiment from others that were unfair but also to justify their view. Furthermore, they were prompted not only to conclude out of an experiment but also to justify their conclusions based on their observations.

**Data collection and coding**

Data were collected using a questionnaire, which consisted of four items, at two time points: before implementing the two focal units (pre) and after implementing them (post). The items were developed in the frame of floating sinking phenomena (items 1 and 2, FS) and magnetic phenomena (items 3 and 4, Magn). Specifically, they were developed to record the student teachers' (a) understanding of the design of a fair experiment to test a variable's influence on a phenomenon (items 1 and 3) and (b) ability to discern a fair experiment from others, which are unfair (items 2 and 4).

Respondents' answers were analyzed according to a bottom-up analysis (Strauss and Corbin 1994), also considering the categories in the relevant literature (Boudreaux et al. 2008; Authors 2017). Answers were coded in a continuum from incoherence in description (coded as 0 in all measurements) to correct description (coded as 3, in terms of expected learning outcomes). Two researchers carried out the data analysis independently, with an 85% agreement, which increased to 100% following discussion.

# RESULTS

The results of the data analysis showed that the experimental group benefited more from the science course. This difference is already apparent in Table 1, which comprises the Means and Standard Deviations of the student teachers' responses to the four items.

Table 1. Means and Standard Deviations of the student teachers' responses to the four items in both groups.

| | Control group (N=40) | | | | Experimental group (N=45) | | | |
|---|---|---|---|---|---|---|---|---|
| | Pre | | Post | | Pre | | Post | |
| Item | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| 1. FS design | .13 | .563 | .23 | .698 | .04 | .298 | 1.24 | 1.334 |
| 2. FS discern | .68 | 1.269 | .70 | 1.181 | .36 | .857 | 2.13 | 1.325 |
| 3. Magn design | .35 | .864 | .50 | .961 | .38 | .777 | 1.53 | 1.290 |
| 4. Magn discern | 1.10 | 1.336 | 1.68 | 1.248 | 1.24 | 1.228 | 2.62 | .806 |

Moreover, the Means' difference in the control and the experimental group is statistically significant in all four items ($p < .001$, Wilcoxon analysis) for the experimental group. On the contrary, student teachers' responses are statistically different ($p < .05$, Wilcoxon analysis) only in the case of the 4$^{th}$ item.

Besides, to check the contribution of being able to discern a fair experiment from unfair ones to understand a fair experiment's design, we proceeded in a linear regression analysis on the experimental group's data only. We took this option because only the experimental group discussed this issue during the implementation, so only these student teachers presented relevant progress due to the implementation. The dependent variable on the linear regression analysis was the responses on the design items, and the independent variable the responses on the discern items for each phenomenon (FS and Magn). In the case of the student teachers' responses before the implementation (pre), the contribution of being able to discern fair from unfair experiments to the understanding of the design of a fair experiment was not statistically significant, neither for the floating sinking ($F_{1,43} = 0.17$, $p = .68$) nor for the magnetic phenomena ($F_{1,43} = 3.07$, $p = .087$). In the case of the student teachers' responses after the implementation (post), being able to discern fair from unfair experiments contributed to 14.4 % and 23,3 % to the understanding of the design of a fair experiment, in floating sinking ($F_{1,43} = 7.25$, $p < .05$) and magnetic phenomena ($F_{1,43} = 13.05$, $p = .001$), respectively.

## DISCUSSION AND IMPLICATIONS

In sum, the results showed that the experimental group's student teachers benefited more from the science course. Besides, in the experimental group, the contribution of being able to discern a fair experiment from unfair ones to understand a fair experiment's design was statistically significant only just after the implementation.

These results allow us to assert that a critical scaffolding to the holistic understanding of the Control of Variables Strategy is the improvement of the ability to discern fair from unfair experiments. Thus, activities that focus on this particular learning goal are essential to be included in a teaching design, at least for the pre-service early childhood teachers' preparation. Examples of such activities are going to be presented at the conference.

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