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Does the Understanding of Managing Variables among Pre-Service Early Childhood Teachers Correspond to Distinct Teaching Methods in Their Future Careers?

Anastasios Zoupidis [1,*], Vassilis Tselfes [2] and Petros Kariotoglou [3]

[1] Department of Primary Level Education, Democritus University of Thrace, 68131 Alexandroupolis, Greece
[2] Department of Early Childhood Education, National and Kapodistrian University, 10676 Athens, Greece; tselfesv@ecd.uoa.gr
[3] Department of Early Childhood Education, University of Western Macedonia, 53100 Florina, Greece; pkariotog@uowm.gr
* Correspondence: azoupidis@eled.duth.gr

Abstract: This study aims to examine the views of pre-service early childhood student teachers (referred to as student teachers) regarding the potential impact of an inquiry-based science course on their intention to utilize inquiry-based learning approaches, such as the Control of Variables Strategy (CVS) method. The study comprised a preliminary phase (N = 17) and a primary phase (N = 81). The participants' level of understanding of the inquiry-based method was assessed using an open- and semi-open questionnaire. A 34-item Likert-type questionnaire was created using the Theory of Planned Behavior in the preliminary phase of the study and utilized in the primary phase to examine student teachers' intentions to include the CVS technique into their lessons. The results showed student teachers' strong intention to implement inquiry-based learning strategies, being supported by their positive estimations of managing the CVS method engagement in the classroom. However, their estimations of the significant others' opinions and the personal gain–loss balance expected from engaging with the CVS method significantly hindered their intention. Most interestingly, the results of the study suggest that the various levels of comprehension of the CVS method attained by student teachers are connected to the adoption of distinct approaches in their future teaching endeavors. In light of these results, we discuss several teaching implications.

Keywords: early childhood; inquiry-based teaching; control of variables strategy; theory of planned behavior

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1. Introduction

The use of inquiry-based teaching and learning environments, where the scientific method and practices serve as both learning objectives and a means of learning, is encouraged by contemporary science curricula at all educational levels [1,2]. These activities, especially in the preschool and primary school years, are essential for a child's social-emotional development and will subsequently help with conceptual science learning [3]. The Control of Variables Strategy (CVS) is a crucial component of scientific research methodology. It refers to the process of creating and carrying out appropriate and fair experiments to examine how a variable affects a phenomenon [4].

For instance, in a CVS-based exercise, one is likely to present a scenario such as "a classmate says that the smoother a floor is, the harder it will be to stop a box that your classmate pushed on it" and then ask the question, "How can we see if he is right or not?" By using such questions, a conversation can be started among the pupils and an agreement can be reached that, once the variables have been decided upon, an experiment must meet certain criteria: (a) consist of at least two trials; (b) vary the variable of interest; and (c) keep all other variables constant in order to be able to draw a safe conclusion [5,6].

It is anticipated that if pre-school and primary school teachers receive their training on science education teaching issues in the context of innovative exploratory environments while studying at the pedagogical departments, their conscious and efficient use of such environments will be improved [7,8]. This seems to be essential because, although young children can use the CVS method, their explorations appear to need sufficient guidance to design multivariable experiments [9,10], especially when they are, for instance, engaged in a more exploratory play-based environment [11].

Investigating the intention and the way student early childhood teachers (referred to as student teachers) intend to use the CVS method in their classrooms is considered crucial [7,8]. The findings of such an investigation can shed light on the impact of their intentions on their teaching practices [12,13]. The Theory of Planned Behavior [14,15] (Figure 1) states that an individual's intention or perspective to engage in a specific activity, at a specific time and location, is determined by three factors: attitudinal factors towards engagement, i.e., estimation of personal gains and losses; normative factors, i.e., subject to the opinions of important others, such as parents, colleagues, etc.; and engagement control factors, i.e., estimation of personal abilities that are a prerequisite for effective engagement.

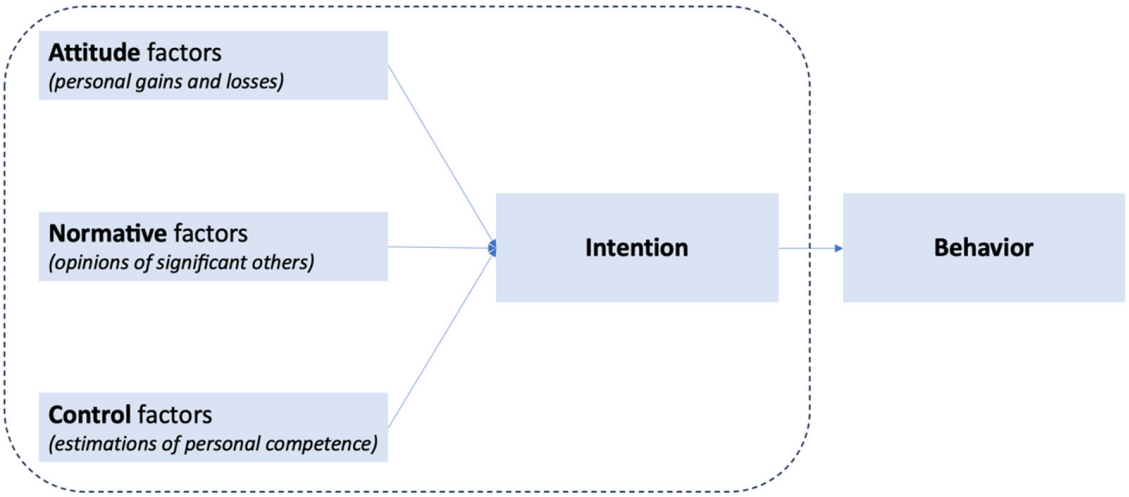

Figure 1. The theory of planned behavior.

Based on the foregoing information, the current study aims to document the views of student teachers regarding the CVS method. It also explores the reasons behind their intentions to integrate this method into their teaching practices and the factors influencing these intentions in relation to their involvement in a pertinent semester-long laboratory course that emphasizes teaching inquiry [16].

2. Method

2.1. Participants

The study was conducted within a university laboratory-type and inquiry-based course, in the context of early childhood science education in a department of early childhood education. At any point during the study, the participants were free to stop participating. The study took place in two phases, with two separate groups of participants, as recommended by Ajzen and Fishbein [14].

The participants in the first, preliminary phase comprised seventeen (17) while in the second, primary phase eighty-one (81) second-year student early childhood teachers, 20–23-year-olds. The student teachers in both phases designed and implemented several inquiry-based classroom experiments concerning phenomena that are usually taught in the curricula of early childhood education, such as floating and sinking (FS) and magnets, investigating, among other issues, the variables that could influence these phenomena [16].

The student teachers were explicitly taught the reasoning of the Control of Variables Strategy (CVS), as one of the goals of the course was to provide a clear understanding of certain aspects of the inquiry-based method [17,18]. The student teachers also had the opportunity to discuss both fair and unfair experiments in order to recognize their differences. For instance, the student teachers were prompted not only to distinguish but also to discern a fair experiment from others that were unfair. Furthermore, they were prompted not only to discuss and draw a conclusion from experiment but also to describe the observations that enabled them to come to this conclusion [16].

2.2. Research Questions

Adopting the framework of the Theory of Planned Behavior, we focused on the following four research questions (RQs), searching for answers that could improve teacher education courses and encourage students to apply what they learn in their future professional lives:

1. What is the student teachers' understanding of the CVS method as a result of the semester-long laboratory-type course? (RQ1)
2. What is the student teachers' intention to use the CVS method when designing and implementing teaching scenarios for science education topics? (RQ2)
3. How is this intention influenced by attitude factors towards engagement (personal gains and losses), normative factors (opinions of significant others), engagement control factors (estimations of personal competence), and their belief in the potential gains or losses that their future pupils will have from implementing this method? (RQ3)
4. Are the different levels of understanding the CVS method, achieved by the student teachers, linked/correlated with different approaches to their future teaching as teachers? (RQ4)

2.3. Questionnaire Development

Ajzen and Fishbein's [14] method for developing questionnaires was employed to investigate student teachers' intention to use the CVS method in their first year of teaching. The first group of student teachers (N = 17) responded to an eight-item open-type questionnaire [16], designed to elicit student teachers' beliefs about using the CVS method in their first year of teaching, focusing on the three categories of socio-psychological factors of the A & F (Ajzen and Fishbein) framework [14,15]. Thus, in the present study the student teachers were asked to indicate:

1. Their personal gains and losses, in the case they used the CVS method;
2. The reasons specific third persons are important for them to approve or disapprove of their teaching choices;
3. The personal factors that would help or impede them from the successful implementation of the CVS method.

In addition to the usual three factors of the A & F framework mentioned above, student teachers were asked to indicate the gains and losses of their pupils in the case they used the CVS method. This way, a fourth factor has been included, referring to the student teachers' beliefs of their pupils' learning outcomes as a result of their inquiry-based teaching.

The student teachers' responses to the open-type questions were compiled and analyzed for content, according to the A & F method, which includes only those ideas representing a majority (75%) of salient beliefs [19,20]. The resulting categories were used to construct a 34-item 5-point Likert scale questionnaire (see Appendix A), which would be used by the second group of student teachers (N = 81) of the study. The purpose of this questionnaire was to investigate student teachers' intention to use the CVS method in their first year of teaching in the context of the A & F framework. The 34 items of this questionnaire can be grouped into four sets, corresponding to the four factors of the A & F framework (pupils' learning outcomes, attitude, normative and control factors), as follows:

1. Seven items were related to pupils' learning outcomes that, in the opinion of student teachers, pupils would gain providing that their teaching practices would include the CVS method. For example, "My pupils would understand the CVS method and the procedure of experiments".
2. Eight items were related to attitude factors, i.e., personal gains and losses. For example, "I would enjoy a pleasant and productive classroom environment".
3. Nine items were related to normative factors, i.e., whether important third persons would approve or disapprove of their teaching choices. For example, "Colleagues would criticize/reject me because the method is difficult".
4. Nine items were related to control factors, i.e., student teachers' estimations about personal factors that would help or impede them from implementing the CVS method. For example, "The implementation of the method would succeed because I have patience and perseverance until the children understand".

The questionnaire, in accordance with the A & F framework, concluded with the following item, which placed the act of teaching in a specific format, in a specific context and time: "In conclusion, kindly consider and check the appropriate box (from "Highly likely" to "Highly unlikely") indicating the likelihood that, during your first year of teaching, you would use the inquiry teaching approach into your classes, as exemplified by the variable management case" (see Appendix A).

The understanding of the CVS method was assessed by the CVS-questionnaire, which consisted of four items (eight sub-items), two open- and two semi-open-type questions, thoroughly described in authors' previous publication [16]. The CVS questionnaire items were intended to confront student teachers with questions whose answer requires the management of more than one variable.

Furthermore, although open- and semi-open-type questions are related to the same phenomena, they have one essential difference. An open-type question does not clearly provide a specific hypothesis to be investigated. More precisely, it does not provide a priori specific variables that may affect the phenomenon; it refers only indirectly to potential variables that have to be constructed and managed by the pupils, namely, through the materials available to answer the question. In contrast, semi-open-type questions provide the variables in advance, through their preconstructed options. So, depending on the answers to the CVS questionnaire, three categories of student teachers can be identified, as follows:

1. Student teachers who do not respond proficiently to any type of question (neither open- nor semi-open types), and who therefore fail to understand any of the steps of the CVS method (category 1);
2. Student teachers who answer only the semi-open-type questions competently, who have succeeded in understanding the CVS method as a simple rule for managing specific variables defined by someone else (rule: only one variable is changed, and the others remain constant) (category 2);
3. Student teachers who answer the open-type questions adequately, in principle, are expected to also have answered the semi-open-type questions adequately, and, in addition, they will have succeeded in constructing the variables to be tested from the available materials in the problem statement, i.e., they will have succeeded in constructing the complex hypothesis to be tested (category 3).

Finally, the analysis of the student teachers' responses to the CVS questionnaire using the factor analysis method should generate three independent axes of thought, one for each student teacher category, and also divide the student teachers into three clusters, corresponding to the categories.

Data concerning the understanding of the CVS method were collected at the beginning (pre) and at the end (post) of each semester. A & F questionnaires were administered at the end of each semester (post), immediately after the CVS questionnaire. Data collection took place in the student teachers' class, following their consent, and after being informed of

the purpose of the study. Participation was voluntary and all student teachers retained the right to withdraw from the study at any time and without giving any reason.

3. Results

The results from the data analysis show that (a) student teachers understand the CVS method in different ways, (b) the intention of student teachers (N = 81) to engage with the CVS method in future school lessons is high, (c) there are groups of factors that strongly influence student teachers' intention to use the CVS method in the first school year they will teach, forming, as expected, differentiated intentions [14,15], and (d) different levels of understanding of the method are associated with different estimations/approaches to their future teaching, mainly related to the potential gains and/or losses experienced by themselves and/or their future pupils.

3.1. RQ1 Results

The factor analysis of student teachers' responses to the CVS questionnaire explains 68.3% of the variability and emphatically shows that student teachers respond with at least two different and independent lines of reasoning. One is found in the open-type questions and the other in the semi-open-type questions (RQ1). These two manners of thinking refer to the student teachers' categories 2 and 3, as presented in the Method section. From the results of the analysis, however, there seems to be an absence of a thinking manner corresponding to the case of the student teachers' category 1. This may mean that these student teachers are very few in number and/or respond without following a specific (and different from the other two) pattern.

Based on the above findings, we tested the hypothesis of segregation of the student teachers into three groups, using K-means cluster analysis. This analysis was conducted in the two-dimensional space created by the independent scores (on a scale of 0 to 3) in the open- and semi-open-type question tests. This analysis, in agreement with the initial hypothesis (see Section 2) and the results of the factor analysis, indeed segregated the student teachers into three groups, as follows:

1. Group 1: inadequate responses to all types of questions (six student teachers with the cluster's center at the coordinates 0.21 and 0.92 on a range of numerical rating scales from 0 to 3);
2. Group 2: inadequate responses to the open-type questions and adequate responses to the semi-open-type questions (29 student teachers with cluster center at coordinates of 0.96 and 2.72);
3. Group 3: adequate answers to all types of questions (46 student teachers with the cluster center at coordinates 2.77 and 2.80).

3.2. RQ2 Results

Student teachers' intention to use the CVS method when designing and implementing teaching scenarios on science education topics in their first school year of teaching (RQ2) (Figure 2) is high, as a strong majority of the participants selected "Highly likely (1)" or "Rather likely (2)" in the corresponding question (see Appendix A, the last item in the Questionnaire). This result is repeated when focusing separately on the two main categories of student teachers (groups 2 and 3).

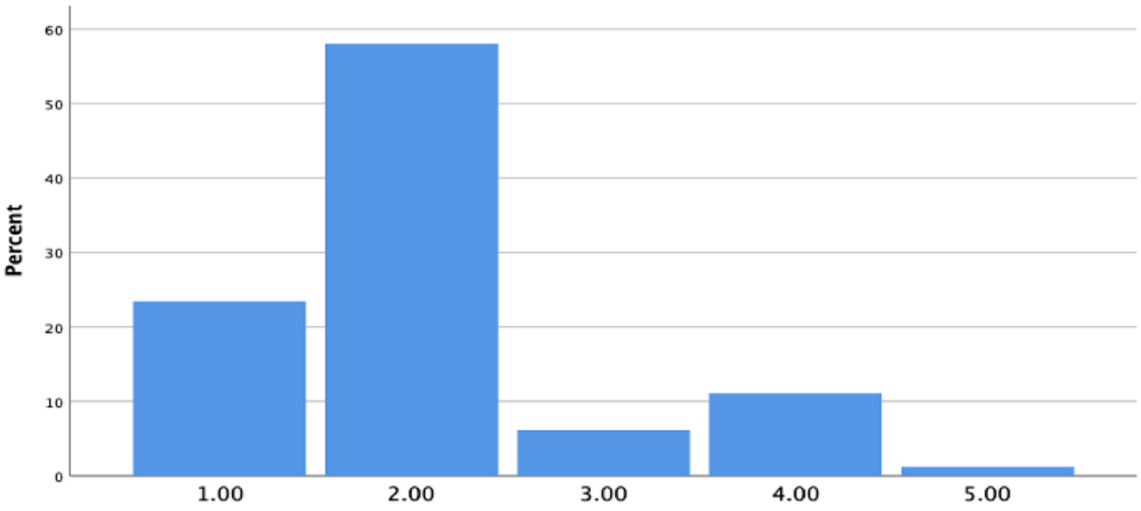

Figure 2. Student teachers' intention to engage with CVS method in their first year of teaching at school.

3.3. RQ3 Results

The way in which the factors of the Theory of Planned Behavior [14,15] influence student teachers' intention to engage with the CVS method (RQ3), was investigated by linear regression analysis, through origin, among all student teachers. As shown by the data analysis, this intention:

1. Is supported by the positive estimation of controlling this engagement ($\beta = 0.305$, $p < 0.001$)
2. Conflicts with the estimation of opinions of significant others about this engagement ($\beta = -0.556$, $p < 0.001$), as well as with the attitude factor, i.e., the estimations of the personal gain-loss balance expected from this engagement ($\beta = -0.205$, $p < 0.05$).

In general, this result is repeated when we focus separately on the two main categories of student teachers (groups 2 and 3). The small number of student teachers, 7.4% of the sample, does not allow us to consider that category 1 provides any significant and representative results. However, it is worth noting that the student teachers who state that they do not intend to use the CVS method in their future courses (options 4 and 5 on the 5-point Likert scale) do not belong to this category of student teachers. On the contrary, they state that it is extremely to very likely to use it (options 1 and 2 on the 5-point Likert scale).

3.4. RQ4 Results

In order to clarify whether the two different levels of understanding of CVS generate or resonate with different views on a future use (RQ4), we decided to analyze, separately for the two groups of student teachers (groups 2 and 3), the four sets of responses to the questions referring to: (a) pupils' gains and losses, (b) student teachers' gains and losses, (c) opinions of significant others and (d) estimations of personal competence. This procedure includes, for each case, a factor analysis to reduce the variables (highlighting unified and independent ways of thinking) and an A & F-type linear regression analysis of student teachers' intention for the variables generated by the factor analysis.

For the first set of questions (set a), which focused on what pupils will gain, the factor analysis (interpreting 55.8% of the v: variance) revealed the following significant and independent ways of thinking for group 2:

1. The pupils' understanding factor (28.0% of v): the pupils will understand without difficulty the scientific method, the experimental procedure, and the concepts, and they will gain skills (a.2.1);

2. The factor of pleasant atmosphere (social interaction) with pupils (27.6% of v): pupils will enjoy a pleasant, interesting, and participatory lesson, gaining new experiences, even at the expense of their free time (a.2.2).

The linear regression analysis (interpreting 82.2% of v) shows that student teachers' intention is positively influenced ($\beta = 0.692$, $p < 0.001$) by the pupils understanding factor (factor a.2.1), while the factor of social interaction with pupils contributes negatively ($\beta = -0.325$, $p < 0.05$), in line to the contribution of time loss estimation.

Similarly, the following significant and independent ways of thinking emerge for group 3 (interpreting 67.3% of v):

1. The pupils' understanding factor (29.4% of v): as for the student teachers of group 2 (a.3.1);
2. The factor of gaining new experiences, even at the expense of free time (19.0% of v) (a.3.2);
3. The factor of enjoyable lessons, even at the expense of free time (18.9% of v) (a.3.3).

The linear regression analysis (interpreting 78.5% of v) shows that student teachers' intention is mainly, although marginally influenced ($\beta = 0.514$, $p = 0.077$), by the factor of gaining new experiences (factor a.3.2) and also by the pupils' understanding factor (factor a.3.1, $\beta = 0.421$, $p < 0.05$). Contrarily, the factor of enjoyable lesson contributes negatively ($\beta = -1.018$, $p < 0.05$) (factor a.3.3).

In summary, both group 2 student teachers, who understood the variable testing aspect of the CVS method as a simple management rule, and group 3 student teachers, who understood the variable testing aspect to be linked to identifying the variable and hypothesis construction aspect of the method, intend to use it in their future classes because they consider that their pupils will understand the method, the experimental procedure, as well as the concepts and phenomena to be negotiated. However, student teachers of group 3 differ substantially from those of group 2 because they seem to consider the new experiences that their pupils will gain as the most important gain for them; contrarily, student teachers of group 2 associate this gain, in general, to the pleasant social interaction that their pupils will experience. Finally, neither group of student teachers perceives this social interaction as a benefit that can influence their intention to implement the CVS method, probably in line with the contribution of the waste of time that it entails.

For the second set of questions (set b), which focused on what student teachers will gain, the factor analysis (interpreting 55.8% of v) revealed the following significant and independent ways of thinking for group 2:

1. Teaching factor (34.8% of v): pleasant and productive atmosphere, enjoyable relationship with children, which improves me as a teacher, although at the expense of both teaching and preparation time (b.2.1);
2. Content factor (21.0% of v): the pupils and I would understand science better, although I would risk exposure from a failure (b.2.2).

The linear regression analysis (interpreting 42.7% of v) shows that student teachers' intention to use the CVS method is positively influenced, although not significantly ($\beta = 0.157$, $p = 0.28$), by the content factor, i.e., the understanding of content by both student teachers and pupils, despite the risk of failure (factor b2.2). Conversely, the teaching factor contributes negatively ($\beta = -0.650$, $p < 0.001$), most probably in line with the contribution of the factor of expected waste of time.

On the other hand, the following significant and independent ways of thinking emerge for group 3 (interpreting 73.8% of v):

1. The relationship with the pupils factor (25.3% of v): pleasant and productive atmosphere, on the basis of which I would enjoy both the help I would provide to the pupils and my relationship with them (b.3.1);
2. The time factor (18.3% of v): waste of teaching and preparation time (b.3.2);
3. The personal learning factor (16.1% of v): improving both my scientific knowledge and my teaching skills (b.3.3);

4. The risk factor (14.2% of v): exposure in case of failure (b.3.4).

The linear regression analysis (interpreting 80.8% of v) shows that student teachers' intention is positively influenced only by the relationship with the pupils factor ($\beta = 0.606$, $p < 0.05$), while the other three factors contribute negatively, although not in a statistically significant way. This is expected for the waste of time ($\beta = -0.323$, $p = 0.17$) and the risk of failure ($\beta = -0.126$, $p = 0.484$) factors. On the contrary, the fact that group 3 student teachers are unable to recognize that the personal learning factor (scientific and instructional) may contribute positively to their intention to implement the CVS method in their future classes ($\beta = -0.132$, $p = 0.577$) was surprising and unexpected.

In summary, group 2 student teachers, who understood the variable testing aspect of the CVS method as a simple management rule, seem to interpret its future use through the simple and classical dichotomy: personal benefits from teaching practice and learning outcomes. Expected learning outcomes inspire them, although slightly, to use the method, while their estimations about personal benefits from such a teaching practice seem to strongly discourage them, most probably due to the waste of time factor. On the contrary, student teachers in group 3 seem to perceive their personal gains and losses in relation to four mutually independent variables, which interpret an extremely high percentage of the variance. It is noteworthy that only the variable regarding beneficial relationships with student teachers' pupils tends to strongly and positively contribute to their intention to use the CVS method in the future. From the remaining three variables that contribute negatively to their intention, we highlight the negative contribution of the personal learning variable (improving both content and pedagogical knowledge). From the authors' perspective, this means that student teachers who adequately understood the CVS method do not consider that they themselves learn by teaching. Perhaps their success in the undergraduate course, which included both pedagogical knowledge and content knowledge, makes them assume that they have acquired all the knowledge required.

For the third set of questions (set c), which focused on the opinions of significant others, the factor analysis (interpreting 70% of v) revealed the following significant and independent ways of thinking for group 2:

1. The friends' and family's opinion factor (29.4% of v): interested third persons, being positive for various reasons (c.2.1);
2. The pupils' parents' opinion factor (23.9% of v): parents' negative opinions (c.2.2);
3. The school environment and stakeholders' opinion factor (16.7% of v): colleagues' negative opinions and pupils' apathy (c.2.3).

The linear regression analysis (interpreting 82.7% of v) shows that student teachers' intention to use the CVS method seems to be influenced, although not significantly, by their friends' and family's positive opinions ($\beta = 0.281$, $p = 0.31$), as well as by pupils' parents' negative opinions ($\beta = 0.365$, $p = 0.34$). Contrarily, colleagues' negative opinions seem to negatively contribute student teachers' intention ($\beta = -1.000$, $p = 0.045$).

On the other hand, the following significant and independent ways of thinking emerge for group 3 (interpreting 56.9% of v):

1. The positive or neutral opinion factor (34.8% of v): from friends, family and/or pupils (c.3.1);
2. The negative opinion factor (22.1% of v): from colleagues and/or parents (c.3.2).

The linear regression analysis (interpreting 77.3% of v) shows that student teachers' intention is positively, although slightly, influenced by the positive opinions ($\beta = 0.050$, $p = 0.77$), while colleagues' and/or parents' negative opinions do not have the weight to positively contribute to student teachers' intention ($\beta = -0.839$, $p < 0.001$).

In summary, group 2 student teachers, who understood the variable testing aspect of the CVS method as a simple management rule, approach the normative factor (the "shoulds") of the A & F theory through the important third persons, paying attention to friends' positive opinions and parents' negative ones. Contrary, student teachers in group 3, who understood the variable testing aspect linked to identifying the variable and

hypothesis construction aspect of the method, approach the normative factor of A & F theory through the positive or negative character emerging from the opinions themselves; that is, they focus on "what is said" rather than "who said it" when elaborating their personal intention to engage with CVS teaching. In this case, student teachers are positively, although slightly, influenced by positive opinions and emphatically resist negative ones. This may be explained by the high self-esteem of student teachers in group 3.

For the fourth set of questions (set d), which focused on student teachers' competency estimations that allow for implementation monitoring, the factor analysis (interpreting 59% of v) revealed, for group 2, the following significant and independent ways of thinking, which influence their intention to use the CVS method in their future classes:

1. The teaching skills (both positive and negative) factor (37.5% of v): patience, perseverance, critical and research perspective, communicability, knowledge of method and theory, classroom management difficulties (d.2.1);
2. The Personal characteristics (both positive and negative) factor (21.5% of v): humor, distraction, anxiety (d.2.2).

The linear regression analysis (interpreting 87.0% of v) shows that student teachers' intention to use the CVS method seems to be positively influenced both by the teaching skills factor ($\beta = 0.969$, $p = 0.00$) and the personal characteristics factor ($\beta = 0.170$, $p = 0.04$).

On the other hand, the corresponding factor analysis (interpreting 59.4% of v) revealed the following significant and independent ways of thinking for group 3:

1. The positive (productive/supportive) abilities (both teaching and personal) factor (35.6% of v): patience, perseverance, humor, critical and investigative eye, communicability, knowledge of method and theory (d.3.1);
2. The factor of negative characteristics and lack of competences (both teaching and personal) (23.8% of v): distraction, anxiety, self and classroom management difficulties (d.3.2).

The linear regression analysis (interpreting 77.2% of v) shows that student teachers' intention is influenced by positive abilities ($\beta = 0.513$, $p = 0.09$), while student teachers' negative characteristics and lack of competence contribute negatively ($\beta = -0.293$, $p = 0.15$), as it was anticipated. This fact may bring to the fore the hypothesis of high self-esteem among the student teachers in group 3.

In summary, group 2 student teachers, who understood the variable testing aspect of the CVS method as a simple management rule, seem to interpret its future use in terms of the persons who possess the abilities and characteristics, while student teachers in group 3, who understood the CVS method in a more sophisticated way, seem to interpret its future use in terms of the positive or negative quality of their abilities and characteristics.

4. Discussion

The aim of this study was to investigate early childhood student teachers' beliefs, on the basis of which they choose to use the CVS method in their first school year of teaching, as a result of a semester-long, laboratory-type, and inquiry-based course. The results show that the CVS method is understood in two different ways: (a) as a simple rule for managing certain, already defined variables (rule: change one variable and keep the others constant) and (b) as a more complex process of simultaneously managing several variables to formulate complex hypotheses and test them with the CVS method. These results are in line with previous studies that have highlighted the difficulty in understanding the CVS method [5,6].

According to the previously mentioned findings, mastering the CVS method as a simple and general rule appears to come before developing the ability to build a complex hypothesis, at least as far as the training of student teachers is concerned. In addition, it seems that it is critical to prioritize the development of competences related to the processes of building complex, sophisticated hypotheses, which logically precede, and subsequently end up being tested by using of the CVS method. Stated differently, the proposal is to move

student teachers from category 2, which involves understanding CVS as a simple rule, to category 3, which involves understanding CVS as a complex process that involves first constructing and then evaluating a hypothesis.

Furthermore, we discovered that positive control estimations of the CVS method engagement—providing good estimations of the student teachers' individual capacity to oversee the CVS method in the classroom—support the student teachers' purpose to interact with the CVS. In contrast, student teachers' intention to engage with the CVS strongly conflicts with their estimations of the opinions of others about this engagement, as well as with their attitude, i.e., their estimation of the personal gain and loss balance expected from engaging with the CVS method. However, this conflict does not occur with the same intensity [14,15]. This image, in our opinion, illustrates how knowledge of the CVS method's content builds expectations for sufficient control over future pupils instruction. However, it is anticipated that this instruction will wear out the teachers individually and present them with substantial social reactions and challenges.

The final point is that the various levels of comprehension of the CVS method attained by the student teachers are connected to the following:

1. The essential distinction between an inquiry-based and a constructivism-based didactic approach; that is, comprehending the variable management rule and the practices that lead up to it (group 3), as opposed to comprehending the rule alone (group 2);
2. The various approaches to their future teaching as teachers can be observed in the following sense: Regarding the individual variables of the A & F theory (pupils' gains and losses, personal gains and losses, third important persons' normative views, implementation control abilities), the student teachers in groups 2 and 3 organize their thinking in different ways. Group 3 student teachers have an elaborated picture of how the variables function based on the logic of inquiry (see Table 1).

Table 1. Teaching results: the two CVS comprehension profiles.

	Group 2	**Group 3**
Gaining knowledge about CVS	CVS management as a content rule	CVS management as an experience activity linked to the rule
Pupils' gains and losses from	1. content understanding 2. pleasant atmosphere with pupils	1. content understanding 2. new experiences 3. enjoyable lesson
Student teachers' gains and losses from	1. teaching variables 2. content variables	1. relationship with the pupils 2. working time needed 3. personal learning acquired 4. risk to be taken
Important persons' normative views	1. friends and family members 2. pupils and their parents 3. colleagues	1. positive or neutral 2. negative
Implementation control abilities	1. teaching skills 2. personal characteristics	1. positive 2. negative

In more detail, group 3 considers the following:

- Pupils' gains include a variable linked to "gaining new experiences" that is distinct from the two traditional and expected variables of pupils' participation in a fun lesson, which the student teachers of group 2 also observe, and pupils' understanding of the content (both declarative and procedural);
- Factors driven by four independent variables (relationship with pupils, time, personal learning, risk) contribute to student teachers' personal gains and losses, rather than just the two traditional and expected variables that group 2 student teachers see (variables organized by teaching/pedagogical principles and content);

- Contrary to what student teachers in group 2 believe, their normative views of significant others are arranged according to how positively or negatively they view their intention to use CVS rather than the social aspects of their relationships (friends, relatives, parents, future student teachers' colleagues, etc.);
- The control skills for CVS implementation are arranged according to their positive or negative impact on implementation, not according to how group 2 student teachers divided them, into teaching and personal competences.

5. Implications

Our courses, which are science education courses in a teacher training department, are estimated to teach the declarative and procedural content of CVS, as well as the dynamics of the teaching-learning context, which student teachers will apply, as they prepare to become teachers, by evaluating the qualities of the knowledge they will need to learn. These findings indicate that the following should be addressed in our next courses on teacher education and training: (a) when possible, ensure that all student teachers acquire declarative and procedural knowledge of CVS in the same manner as group 3, rather than group 2; (b) encourage critical opinions about how CVS (pupils' gains, attitudinal, normative, control) should be applied in the future to all the variables that the group 3 of student teachers indicated. Specifically:

a. In regard to the variable of "new experiences" that the students in group 3 are expressing, it would assist to talk about and emphasize the experience of a "critical experiment" (since these are the focused ones), its drawbacks, its "revelation," and our skepticism regarding the outcome. Regarding the magnets, for instance, there is a conjecture as to what kind of proof would lead us to believe that one is stronger than the other: is it the one that draws the furthest away? Does it draw the greatest number of items? Is there any effect from the friction on the table? Considering that a CVS process, being an investigative process, begins with an inquiry, produces hypotheses, and culminates in a "critical experiment".
b. Regarding the variables related to teachers' personal benefits—which are also observed in the student teachers in group 3—it would be beneficial to take the teacher's side and talk about how the teacher interacts with pupils, qualifying for the inquiry (and CVS) processes with a genuine attitude of assisting students in the process of answering a question by framing a critical experiment. It would also be crucial to discuss management concerns pertaining to the teaching and learning process and preparation times, preferably using specific instances from our own experiences. Lastly, it would be critical to gather and share with our pupils any lessons we may have gained from instructing them, as well as the risks we took and their success rate.
c. Regardless of which significant third parties voice them, it would be of benefit to discuss both the positive and negative opinions about our courses.
d. By downplaying methods that mention personalities and psychological traits, it would be valuable to talk about our own strengths and weaknesses in managing and controlling the development of a teaching-learning process.

It is important to note, finally, that the analyses above demonstrate how the development of the declarative and procedural scientific content for CVS learners goes hand in hand with the creation and comprehension of extra implicit procedural knowledge from the teaching process that served as the catalyst for learning. In other words, mastering the creation of explicit content likely entails mastering the creation of implicit elements from the procedural-didactic content that underpins it.

Further research could investigate the contribution of the implications mentioned above. Moreover, it would also be of great interest to investigate if the student teachers do in fact implement the CVS method and if they actually feel the same after they have had an opportunity to actually try the method in practice.

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Appendix A

The A & F questionnaire's introductory text

Please provide input on the following predictions if, during your first year of teaching at the school, you used the inquiry method in your lessons, as was indicated in the case of variable management, for example. On the agree-disagree scale (1. "Strongly Agree", 2. "Agree", 3. "Neither agree neither disagree", 4. "Disagree", 5. "Strongly Disagree") that follows each prediction, check the relevant box indicating your level of agreement or disagreement.

The 34 items of the A & F questionnaire

Set a: items related to pupils' gains/losses.

Q1: My pupils would understand the CVS method and the procedure of experiments.

Q2: My pupils would understand concepts and phenomena.

Q3: My pupils would develop skills of the scientific method/inquiry.

Q4: My pupils would gain new experiences.

Q5: My pupils would enjoy an entertaining, interesting, and engaging lesson.

Q6: My pupils would find it difficult to understand.

Q7: My pupils would waste some of their free time.

Set b: items related to student teachers' personal gains/losses.

Q8: I would enjoy a pleasant and productive classroom environment.

Q9: I would be satisfied and happy for the help I give to the pupils.

Q10: I would enjoy interacting with the pupils.

Q11: I would understand the science better.

Q12: I would expand my potential as a teacher.

Q13: I would waste teaching time until I could get the students to understand the method.

Q14: I would lose time for preparation (to gain knowledge or to prepare the experiments).

Q15: I would risk being disappointed, discouraged or even lose some of my confidence if I didn't succeed.

Set c: items related to significant third persons approval/disapproval.

Q16: Parents and relatives of the pupils would praise me for the improvement they would see in their children.

Q17: My family and friends would praise me for my qualities and abilities.

Q18: My family and friends would praise me for my professional development.

Q19: My family, friends and colleagues would praise me for my understanding of the importance of the method.

Q20: My colleagues would criticize/reject me because they don't understand the importance of the method.

Q21: My colleagues would criticize/reject me because the method is difficult.

Q22: Pupils' parents would criticize/reject me because the method is dangerous for their pupils' age range.

Q23: Pupils' parents would criticize/reject me because the method is extreme for their pupils' age range.

Q24: The pupils would be indifferent.

Set d: items related to student teachers' estimations of controlling the implementation of the method.

Q25: The implementation of the method would succeed because I have patience and perseverance until the pupils understand.

Q26: The implementation of the method would work because I have a sense of humor.

Q27: I possess a keen research and critical thinking eye, which makes the method's implementation successful.

Q28: The implementation of the method would succeed because I have the ability to communicate.

Q29: The application of the method would succeed because I have knowledge of the method and theory.

Q30: The method would not work because I have difficulty managing myself (distraction, first-time anxiety, lack of patience, etc.).

Q31: Implementing the method would not work because I find it difficult to manage the classroom (creating interest, children's indifference, ensuring safety in experiments, etc.).

Q32: The application of the method would be successful if the school had suitable facilities and materials available for the experiments.

Q33: Implementing the method would work if I had a small number of students.

Questionnaires' final items' text

In conclusion, kindly consider and check the appropriate box (1. "Highly likely", 2. "Rather likely", 3. "I cannot decide", 4. "Rather unlikely ", 5. "Highly unlikely") indicating the likelihood that, during your first year of teaching, you would use the inquiry teaching approach into your classes, as exemplified by the variable management case.

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