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Impact of a Critical Thinking Program on High School Students in the Biobío Region

Impacto de un programa de pensamiento crítico en estudiantes de un liceo de la Región del Biobío

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Abstract

A program aimed at measuring the development of critical thinking abilities in students of a Chilean high school was evaluated. The study employed a quasi-experimental design with an experimental and a control group, as well as pre- and post-intervention measurements. The participants were 30 secondary school residing in the Biobío region, Chile. A Spanish version of Halpern's HCTAES was used to measure critical thinking. The program, based on Fe y Alegria's experience in Colombia, was administered in 10 sessions (one per week) lasting 45 minutes each. Data analysis included descriptive statistics and analyses to compare means. No significant differences were observed between groups in the pre-test intervention. However, significant differences were found in favor of the experimental group in the post-test intervention regarding the global construct, as well as in three of the four sub-skills. In conclusion, the program had an impact on critical thinking, although it is hypothesized that the small difference found between probabilities may be related to maturation processes, as well as to curricular factors.

Keywords: critical thinking, secondary school students, evaluation

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Resumen

Se evalúa el impacto de un programa de pensamiento crítico en estudiantes secundarios de un establecimiento chileno. El diseño utilizado en el estudio fue cuasiexperimental, con un grupo experimental y de control, con medición pre- y postest. Los participantes fueron 30 estudiantes de segundo medio de un liceo de la Región del Biobío, en Chile. El instrumento usado para medir el pensamiento crítico fue el HCTAES de Halpern, en español, adaptado a 20 situaciones-problema; el análisis de información se realizó con estadística descriptiva y análisis de comparación de medias. El programa aplicado se basó en una experiencia de la ONG colombiana Fe y Alegría; consistió en diez sesiones de 45 minutos, una vez por semana. Los resultados muestran que en la medición pretest no hay diferencias significativas entre los grupos experimental y de control, mientras que la evaluación postest arrojó resultados a favor del grupo experimental en el constructo global, así como en tres de las cuatro subhabilidades, encontrándose diferencias estadísticamente significativas. Se concluye que el programa tiene impacto en el pensamiento crítico, tanto a nivel general como en las subhabilidades, aun cuando no se encontraron mayores diferencias en las probabilidades, lo que podría estar relacionado con factores madurativos y curriculares.

Palabras clave: pensamiento crítico, estudiantes secundarios, evaluación

The demands of today's society, focused on the ability to generate scientific skills, foster participation, increase people's knowledge level, and adapt to diversity, require individuals who are capable of thinking autonomously and who possess high-level cognitive skills, because they must address increasingly complex and diverse social situations (Medina & Domínguez, 2006; Yang & Chung, 2009).

Critical thinking is a set of cognitive skills that make it possible for people to analyze and evaluate data obtained from reality, verifying their validity, consistency, and veracity (Ding, 2014). This involves being able to recognize the information obtained, distinguish the elements that comprise it, verify its sources, and assess its coherence and pertinence. In order to do this, it is necessary to evaluate not only the information obtained but also the use of one's own cognitive skills (Madariaga & Schaffernicht, 2013).

The development of skills such as those noted above should be prioritized given the urgent changes required in the educational field, in order to foster a greater level of professionalism and develop policies that lead to the promotion and use of these skills as part of the school curriculum (Stapleton, 2011). This would also help to improve the quality of learning, and would thus increase students' performance by developing their autonomy and self-efficiency (Ku & Ho, 2010; Olivares, Saiz & Rivas, 2013; Yang & Chung, 2009).

Nevertheless, very few studies or experiences have been conducted in Chile showing how this skill should be developed in the educational field (Miranda, 2003), and it is therefore crucial to increase research in this area.

Critical thinking

Critical thinking is hard to define as a concept, because it can be approached from several perspectives (Paul & Elder, 2003): on the one hand, as a process involving logical and scientific thinking; on the other, as a process enabling one to reflect or philosophize, or even as a type of anti-establishment or rebellious response (López, 2012).

It is also defined as a complex type of cognitive processing, comprised by inter-related subprocesses that make it possible to make assessments, process information analytically and reflectively, make judgments, and accept or reject information produced in social contexts or included in scientific articles (Ding, 2014). It is a way of thinking in which the subject improves the quality of the process by taking control of the underlying structures of the processing act and applying intellectual standards to them (Paul & Elder, 2003).

In addition, it is regarded as a thinking skill that allows individuals to assess the merit, precision, and/or authenticity of the information being learned or generated, and thus constitutes a relevant skill for the development of science professionals (Cassany, 2005). In this regard, it is a form of thinking oriented towards information and action within a context characterized by problem-solving and interaction with others (Daniel & Auriac, 2012; López, 2012).

Critical thinking is self-directed, self-disciplined, self-regulated, and self-corrected; it involves submitting oneself to rigorous standards of excellence and consciously controlling its use, and also requires effective communication and the development of problem-solving skills (Saiz & Rivas, 2008). In addition, it requires a commitment to overcoming the natural egocentrism and sociocentrism of human beings (Paul & Elder, 2003).

Critical thinking is also considered to involve questioning the state of affairs and having an interest in the foundations of ideas, actions, and judgments, both one's own and those of others; in this regard, it is also a sophisticated process that includes, skills, disposition, and metacognition (Dwyer, Hogany, & Stewart, 2012; López, 2012).

Critical thinkers are characterized by knowing how to formulate vital problems and questions, having clarity and precision with respect to information, accumulating and assessing relevant information, using abstract ideas to use such information effectively, reaching conclusions and devising solutions after testing them with relevant criteria and standards, keeping an open mind with respect to alternative ways of thinking, and recognizing and evaluating, as necessary, any assumptions, implications, and practical consequences. Thus, when devising solutions to complex problems, critical thinkers are capable of communicating effectively (Madariaga & Schaffernicht, 2013; Paul & Elder, 2003).

It can then be stated that the central characteristics of critical thinking are, firs, the inferential assessment of arguments, which involves the use of cognitive processes for recognizing and assessing the components of information (Yang, 2012). This requires determining whether arguments are coherent and whether they are based on reasons supported by personal opinions, while also evaluating the quality and quantity of such support. In order to do this, individuals must possess metacognitive skills, which many models regard as an implicit element in this evaluative component (Daniel & Auriac, 2012; Paul & Elder, 2003), even though they are considered to be explicit and slightly different from evaluation in other models (Dwyer et al., 2012; Saiz & Rivas, 2012).

Another characteristic of critical thinking is reasoning, which is linked to the information analysis process and makes it possible to produce and review hypotheses for understanding the relationships between the constitutive elements of information, as well as the relationship between such information and its consequences.

The third element that has been mentioned is argumentative ability, or the capacity to organize valid and pertinent information around a logical argument that makes it possible to convey information (Tiruneh, Verburgh, & Ellen, 2014). Argumentation is a process that involves organizing and contrasting ideas and which makes it possible to support positions upon the basis of propositions that reveal elements that can be used both for justifying and rejecting a proposal, thus leading to a critical and reflexive point of view (Larraín, Freire & Olivos, 2014).

The fourth element to be mentioned is decision-making, a skill related to problem-solving which is based on the assessment of information and its use in later decisions when tackling a complicated situation (Antequera, 2011; Olivares & Heredia, 2012). This component involves decision-making, creativity, and analysis skills used in a systematic evaluative judgment that should allow students to identify the best solutions (Tiwari, Lai, So, & Yuen, 2006).

Lastly, a fifth element has been hypothesized to belong to this critical thinking macro-skill, as Reguant (2012) has defined it due to its complexity. Nevertheless, this last element has not been widely accepted by all the scholars involved in generating the concept, since it is regarded as an additional element separate from critical thinking as a cognitive skill. This component is a person's disposition or motivation to think critically, which has been defined as a crucial element for the application or preservation of the skill (Saiz & Rivas, 2008; Valenzuela & Nieto, 2008). This element was not included in the study given the low degree of consensus currently attached to it.

Critical thinking programs in secondary school students

Critical thinking is a skill linked to higher cognitive skills (Marin & Halpern, 2011; Paul & Elder, 2003), which has led researchers to see it as a skill that requires a high level of intellectual maturity (Sierra, Carpintero & Pérez, 2010). This has resulted in several studies intended to develop and measure critical thinking in university students, professionals, or adults (Ku & Ho, 2010; Sánchez, 2012; Stapleton, 2011; Tiruneh et al., 2014), with less emphasis being placed on the work that can be conducted in primary and secondary education.

Multiple studies carried out for strengthening critical thinking in secondary school students (Beltrán & Torres, 2009; Daniel & Auriac, 2011; Marin & Halpern, 2011; Yang & Chung, 2009) have revealed that adolescents possess intermediate levels of critical thinking development, which can be improved with training. This is an important aspect, but one that is not often part of the work done in secondary school. It has been pointed out that the educational system should improve the development of skills such as critical thinking, but the political and curricular logics of the educational field prevents this from happening (Marin & Halpern, 2011).

Beltrán and Torres (2009), in a sample of secondary school students in Colombia, observed that adolescents' (inductive-deductive) reasoning sub-skills were adequately developed in terms of hypothesis formulation, argumentation, and decision-making; however, they found low development levels for the likelihood and uncertainty skill. Likewise, Yang and Chung (2009), in a sample of secondary school students in Taiwan, observed an adequate development level in (inductive-deductive) reasoning, inference, and interpretation skills, whereas the most underdeveloped skills were assumption recognition and assessment.

Critical thinking program based on skills for life

The critical thinking program used in the present study is based on a program called "Learning to Be Critical" [«Aprendiendo a ser crítico»], developed by the Colombian NGO Fe y Alegría [Faith and Happiness]. It employs an educational approach (integral popular education) based on the so-called «critical» types of pedagogy. It does not adopt a single psychological, sociological, or philosophical theory; instead, several sources are used to obtain elements that make it possible to introduce the development of children›s and young people›s critical ability to schools (Bravo, 2015).

This choice is intended to result in the construction of a type of individual thinking (conducive to autonomy) that allows students to analyze information, not accepting it naively but instead challenging its veracity, in order to establish a conversation of different types of knowledge that provides them with a personal view of life and of their own circumstances. Critical thinking, from this perspective, is a skill that makes it possible to address the difficulties of today›s society due to its interaction with other skills such as self-esteem, communication, assertiveness, and empathy; as a whole, they are known as *skills for life* because they constitute a set of skills that a person can use to participate effectively in today's world (Bravo, 2015).

The program adapted and administered to the Chilean environment in this study comprised ten sessions lasting one pedagogical hour (45 minutes) each, scheduled over ten weeks. The sessions were organized with four major aims in mind: to identify the participants' research abilities, to strengthen their information analysis, to allow them to distinguish central elements from secondary ones, and, lastly, to help them to argue for and against a given position. Each of these objectives was covered in two sessions, with a work methodology focused on individual reading, analysis, and discussion activities, leaving the first and last sessions for introducing and closing the workshop, respectively.

Method

Design

The design used is quasi-experimental, with a control group and pre- and post-intervention assessments. This design makes it possible to control both for the variables measured and for most of those that might have an impact on the results obtained. Nevertheless, the participants are not randomly assigned to the groups because not all students are interested in participating, nor do they have their parents' permission to do so; therefore, the experimental group must include only those students who meet such requirements.

Population and sample

The target population of the study is made up by tenth grade students attending a rural school in the commune of Yungay, Biobío Region, Chile. The initial projected sample comprises 30 students from this educational level, out of whom 12 were part of the experimental group and 18 of the control group. In this sample, 65% of the participants are female and 35% are male, and their ages range from 14 to 16 years.

Instruments

The instrument used for the pre- and post-intervention measurements was the Halpern Critical Thinking Assessment in Everyday Situations [HCTAES], translated into Spanish by Morales (2011). This instrument comprises 25 problem scenarios to which subjects must provide closed or open-ended answers. Apart from measuring the construct of critical thinking as a global skill, the test measures five specific dimensions associated with this construct (verbal reasoning; argument analysis; thinking as hypothesis testing; likelihood and uncertainty; decision making and problem solving). Some studies (Morales, 2011; Nieto, Saiz & Orgaz, 2009) report that the instrument is sufficiently reliable (Cronbach's alpha =0.7083 and =0.774, respectively). However, the reliabilities of the skills associated with the construct are lower (Cronbach's alpha values ranging from 0.34 to 0.63) (Nieto et al., 2009). In this study, the instrument was applied with a variation proposed by Marin and Halpern (2011) for working with secondary school students: applying the instrument to 20 problem scenarios (verbal reasoning, argument analysis, thinking as hypothesis testing, likelihood and uncertainty), leaving out decision making and problem solving.

Procedure

First, contact was made with the school to request formal written permission to conduct the study. Afterwards, an informed consent form was submitted to the parents of the tenth grade students, detailing the objectives of the study, the modes of participation (assessment only for the control or evaluation group and participation for the experimental group), and the ethical guidelines followed to ensure the voluntary nature of participation and data confidentiality. In addition, the students who participated gave their informed assent to manifest their interest in joining the intervention activity. These ethical considerations were reviewed by an academic group from Universidad del Biobío within the context of the evaluation and defense of a thesis for obtaining an MA in Education in said institution.

Once the consent and assent forms were received, the experimental group was set up. The intervention was scheduled to be conducted on a date and at a time outside of normal school hours, after receiving confirmation from the Principal's office. The participating students' parents were informed of these arrangements.

The modified HCTAES questionnaire was administered, as a pre-test, to all the participants who had given their assent and whose parents had given their consent (18 in the control group and 14 in the experimental group) during a class session provided by one of the school's teachers. Afterwards, the intervention was conducted as a workshop lasting one pedagogical hour (45 minutes) once per week, during ten weeks.

The workshop was implemented with the aid of the Principal's office and a teacher, and its activities were supervised by one of the researchers. The sessions involved the use of written material, case analyses, and research activities conducted individually and in groups. Two weeks after the completion of the workshop, the modified HCTAES questionnaire was administered as a post-test.

The data were analyzed using descriptive statistics (central tendency and dispersion measures), comparing the mean scores of both groups in the post-test assessment of each sub-skill as well as their general critical thinking scores, with a one-way ANOVA. In addition, the test's assumptions, such as sample normality and homoscedasticity, were examined (the former with skewness and kurtosis and the latter with Levene's test).

Description of the workshop

The workshop comprised ten sessions adapted from the original program produced by the NGO Fe y Alegría for use with the group of Chilean students. Two sessions (initial and final) were used to introduce and close the workshop, respectively, and focused on providing information about the process and assessing it. The eight remaining sessions concerned the topics covered by the program, with two sessions being devoted to each.

Even though the original names of the sessions were preserved, the objectives and activities were changed to adapt them to the context of the student population studied. The first topic, called «My investigator's magnifying glass», focused on researching and developing hypotheses based on the available data. The second topic was «I construct my point of view», which concerned argumentative analysis skills. The third topic was called «Infrared glasses for discovering prejudices», and was devoted to argument evaluation and verbal reasoning skills. Lastly, the fourth topic was entitled «Binoculars for foreseeing possibilities», which covered likelihood and uncertainty.

Each session had a similar structure that included the following parts: an introduction to the topic, during which conceptual aspects were explained; a brainstorming section intended to activate previous knowledge; an application activity in which students practiced the skill associated with the topic; and finally, a closing section during which some of the activities conducted were reviewed, the students received feedback, and the tutor closed the session.

The materials used were texts prepared by the tutor, complemented with Internet news stories collected by the participants, question sheets, and observation records of the educational context completed by the students who participated in the workshop.

Results

In general terms, the descriptive analysis revealed a low average performance rate, less than half of the expected level of achievement, both in the pre-test (M = 49.93) and in the post-test (M = 57.83), considering a total score of 125 points. In addition, a relatively normal distribution was observed in both groups, with skewness and kurtosis values ranging from 2 to -2, which is usual for normal distributions according to Bollen and Long (quoted in Núñez-Alonso, Martín-Albo & Navarro, 2007). Complementarily, the Kolmogorov-Smirnov test was applied to assess the normality of the samples in both measurements. This yielded a normal distribution in the pre-test (Z = .838, p = .484) and in the post-test (Z = .435, p= .991).

Table 1
Results of descriptive statistical tests, pre- and post-test

	Hypothesis use		Verbal reasoning		Argumentation		Likelihood and uncertainty		Total	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
N	30	30	30	30	30	30	30	30	30	30
Mean	16.87	21.03	7.80	8.73	17.57	19.70	7.70	8.37	49.93	57.83
S. D.	4.431	5.116	2.024	4.008	3.928	7.082	3.715	4.303	8.867	14.353
Skewness	1.132	-.605	.132	-.314	.447	.132	-.148	.409	1.318	.282
Kurtosis	2.350	-.397	-.559	-.730	.082	-.490	-.345	.216	2.563	.552

In order to identify significant differences between the groups, Levene's homoscedasticity test was conducted. The test showed that this requirement is met in both the experimental ($F[1,22] = .419$, $p = .524$) and the control groups ($F[1,34] = .292$, $p = .593$). Regarding differences between the groups, Table 2 shows that in the pre-test measurement the means of both the sub-skills and the global construct are similar in the experimental and the control group, although they are slightly higher in the former. Nevertheless, the variance analysis of the results of the pre-test shows that such differences are non-significant; thus, in can be inferred that both groups had a similar behavior in terms of critical thinking before the intervention.

Table 2
Results of variance analysis, pre-test

	Experimental group	Control group				
	Mean	Mean	Df 1	Df 2	F-test	Sig.
Hypothesis use	17.1	16.7	1	28	.046	.831
Verbal reasoning	8.6	7.3	1	28	3.226	.083
Argumentation	18.6	16.9	1	28	1.357	.254
Likelihood and uncertainty	8.3	7.3	1	28	.573	.456
Total	52.6	48.2	1	28	1.838	.186

* $p < 0.05$

The post-test analysis revealed larger differences between the experimental and the control group in terms of the mean scores obtained in the *hypothesis use*, *verbal reasoning*, *argumentation*, and *global result* sub-skills. However, even though the experimental group obtained a higher mean score in the likelihood and uncertainty sub-skill, the difference is less marked than in the other sub-skills. The variance analysis showed statistically significant differences between the groups in the three sub-skills mentioned first, which suggests that the experimental group performed differently from the control group on these areas. Only the *likelihood and uncertainty* sub-skill displays a higher significance level than the probability selected ($F[1,28] = 0.546$, $p = 0.466$), which suggests that there were no significant differences between the groups in connection with this skill.

Table 3
Results of variance analysis, post-test

	Experimental group	Control group				
	Mean	Mean	Df 1	Df 2	F-test	Sig.
Hypothesis use	23.5	19.4	1	28	5.347	.028*
Verbal reasoning	10.9	7.3	1	28	7.205	.012*
Argumentation	23.1	17.4	1	28	5.231	.030*
Likelihood and uncertainty	9.1	7.9	1	28	.546	.466
Total	66.6	52.0	1	28	9.650	.004*

* $p < 0.05$

Discussion and conclusions

The development of critical thinking is a process that allows people to strengthen their thinking skills and achieve greater autonomy in sociocultural processes, because it provides them with tools for analyzing the information available in their environment and assess its coherence and pertinence, as well as its aims and orientations. It is important as a social skill, and for this reason the Colombian organization Fe y Alegría has added it to the basic skills that a person requires to live successfully (Bravo, 2015).

This type of program is essential in educational settings; nevertheless, it is not part of the school curriculum in Chile, nor has it been explicitly proposed in educational policies for primary and secondary education (Miranda, 2003). Thus, considering the scarce evidence available in the country about this issue, it is encouraging to observe that such programs can be adapted and administered to the Chilean school population.

It is interesting to note that the average pre-test performance of the participants was low, although this is to be expected in secondary school populations according to studies with similarly-aged samples (Beltrán & Torres, 2009; Marin & Halpern, 2011). However, considering that the population studied resides in an area with high levels of rurality and social vulnerability, which can be associated with less sociocultural stimulation and learning efficacy (Castro & Cano, 2013; Román, 2003), it must be pointed out that the students included in the experimental group managed to significantly increase their scores in the final measurement. This shows with some certainty how important and useful it is for these students to have more extensive and more systematic support for skills such as those strengthened in the cognitive development program examined.

The results reflect the positive impact of the program on the development of critical thinking skills, at a global level and in the majority of the skills; therefore, the program can be said to contribute to the development of critical thinking in secondary school students, an area which has received scarce attention in Chile. The workshop made it possible to develop, effectively, critical thinking skills in students through activities focused on research and hypotheses (topic one), argumentation (topic two), and verbal reasoning (topic three). The activities were reported by the students to be interesting and relevant, because they focused on issues close to their interests and socio-cultural context.

Regarding the above, the fact that a significant level of development was achieved in the hypothesis use, argumentation, and verbal reasoning sub-skills shows that the academic development of young people may benefit from the program, given that these aspects are associated with skills that are essential for deep learning and scientific learning (Larraín, 2009; Valenzuela, 2008).

Only the likelihood and uncertainty skill (topic four) was not effectively developed. This situation may be due to maturational factors, because it is linked with high abstraction capacity, a cognitive capacity whose development, from a Piagetian perspective, is believed to be incipient in the age group of the participants (Carretero, 2000). On the other hand, the reason may also involve school and curricular

factors, because the educational process usually focuses on the acquisition of known contents, often disregarding the uncertainty process, which does not help to strengthen the development of probabilistic thinking (Labarrere, 2006; Nieto, 2002). Explanations associated with differences in the length or structure of these sessions should be dismissed, because their duration was the same as that of the rest of the sessions and they had a similar structure. It must be pointed out that Beltrán and Torres (2009), in a sample of Colombian adolescents, observed the same difficulty with probabilities and uncertainty over the course of a critical thinking program. These researchers ascribed such results to the abstract nature of the topic and the lack of interest in the development of the mathematical reasoning skills that underpin this skill.

In general terms, and with respect to the objective of the study, the above suggests that there is sufficient evidence to claim that the critical thinking program based on the model devised by Fe y Alegría was effective for developing critical thinking in the group of secondary school students included in the study.

Bearing in mind the limitations that affected the study, such as the small number of participants, its quasi-experimental design with intact groups, and the participation of the researchers themselves in the administration process, the results obtained cannot be extrapolated to the rest of the population. Nevertheless, it is an interesting contribution to the research on this subject. Future studies should employ larger samples and cover other educational levels, and also generate a model in which teachers conduct the activities included in the program, thus allowing them to replicate the results obtained in this research. In addition, it would be useful to compare the performance of students who attend different types of school.

Lastly, it would be relevant to examine the relationship between critical thinking sub-skills and other cognitive factors and socio-educational variables, because it is greatly necessary to include such skills in the Chilean school curriculum explicitly and formally.

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