Learning by Imitation: An Alternative of Improvements in Scientific Knowledge

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In the work, the scientific knowledge of novice researchers was improved by applying an educational model that evidenced the effect of connectivism mediated by individual learning and imitation of an expert researcher. The use of standardized questionnaires and application of structural equations achieved correspondence between the theoretical-practical models evidenced by SRMR= 0.0217, CFI= 0.983, TLI= 0.973, RMSEA= 0.092, being confirmed by Hayes' mediational model with; indirect effect of 0.3610 significant, limits (0.1111 - 0.1691), computed with 10 000 bootstrapping. It is concluded that the application of the educational model succeeds in consolidating the scientific knowledge of novice researchers.

Keywords: experiential learning, intentional learning, social learning, knowledge, model building

INTRODUCTION

Imitation learning, also known as vicarious learning, is studied herein as an activity novice researchers use to achieve scientific knowledge – CC. When these researchers develop a research paper, they are generally inaccurate regarding CC proficiency, leading to frustration during publication.

A novice should begin understanding CC by identifying a study problem and phenomenon, understanding the factors that support the referred phenomenon, knowing its current situation, evaluating the knowledge gap, proposing an option to improve the study, justifying its significance, and proposing the objective of the study.

Knowing this process means understanding its workflows and achieving technical experience in the theoretical and empirical aspects of CC, which novice researchers must learn at university.

When the novice fails to understand, it will be evident that these students become uncompetitive and frustrated, as it will be perceived that the learning, they received has been meaningless for achieving their personal development, thus having few chances of contributing to society (OECD, 2006; Ruiz and Torres, 2005).

To attain significant learning, the novice must participate in research competence programs (PCI) that include the scientific method, individual learning skills, the study of a phenomenon, and the referential framework.

(1) *Scientific method* - knowing its components and achieving its proficiency.

(2) *Individual skills* - ubiquitous, invisible, connectivist, and vicarious learning.

Ubiquitous learning is accomplished by using the interaction between students with the support of different communication platforms, Diez-Gutierrez and Diaz-Nafria (2018).

Invisible learning enables students to develop skills such as cooperation, empathy, critical thinking, and fact memorization (Cobo and Moravec (2011).

Connectivist learning (CO) considers the distribution of knowledge through the use and application of a network of connections worldwide, making learning human, relevant, practical, and meaningful (Siemens, 2006).

Vicarious learning is achieved by observing others; this type of learning has broad and significant effects such as direct learning and the acquisition of new responses (Bandura, 1986).

(3) *To evaluate the phenomenon, it is necessary to understand the general-purpose topic.*

As for the *referential framework*, this aspect aims to create learning objects (Ton et al., 2010).

The PCI effect on novices is evidenced by their active participation in imitating the expert researcher; through the assistance of their professor or tutor (terms used in this study), they reach the CC that the effect of the CO factor can massify through MOOCs (Massive Online Open Courses), thus generating digital literacy (AlDahdouh et al., 2015; Siemens and Tittenberger, 2009; Yakhlef, 2009). Another factor will be individual learning (AI) which, along with the aforementioned individual skills, applies cognitive, metacognitive, and affective aspects.

Cognitive aspects with learning strategies and metacognitive aspects through self-regulation. The affective aspects with stress control and alignment of the past with the present (Gargallo Lopez et al., 2020).

PCI, as well as the effect of CO and AI on CC, will generate an Educational Model that should aim at understanding the CC, subsequently, its assessment with the analysis of its research products (NRC, 2002; UNESCO, 2015).

Vicarious or imitation learning applications and impact on CC were found, such as the collaborative PhD in Nursing program between St. Luke's International University from Japan and the University of North Carolina from the USA.

Regarding Science Knowledge,, one was found using medications and CO-AI-CC (Yeo et al., 2021; Badrinarayan, 2022; Eaton et al., 2017; Yildirim and Bakırcı, 2021; Bakırcı et al., 2017; Shu-Jou, 2011; Valero et al., 2020).

The significance of vicarious learning is evident, but no studies on vicarious learning applied to the proficiency of the scientific method were found, particularly those focused on the learning of a novice researcher to reach the understanding of a CC. Therefore, the following question arises:

> Does learning based on imitation of an expert researcher facilitate understanding and explanation of a phenomenon supported by the scientific method and demonstrate the acquisition of new knowledge supported by current paradigms?

The novice may reach this understanding and explanation when learning how experts execute the process that allows knowing a phenomenon, for instance, when dealing with the "introduction" component using the scientific method related to connectivism. It is also possible that the expert will provide a detailed explanation starting from the definition of the problem of a phenomenon under study to the definition of the objectives, including the research question.

It will be evident that it is a form of acquiring new knowledge with the capacity to generate projects that address the same question with different approaches or different questions with similar approaches (Griesemer and Barragan, 2022).

If learning by imitation of an expert allows the novice researcher to acquire new knowledge and research competence, the educational model would guarantee the CC of the novices with the tutor's assistance. The applications of vicarious learning are clear evidence of these achievements.

This paper demonstrates that the application of learning by imitation achieves a good understanding of CC and can be spread by integrating it into an educational model and a PCI.

To measure the understanding, the model uses quality instruments proven by their external and construct validity; it determines that each instrument has strong reliability, ensuring the measurement of each sample subjected to the survey.

The objective was to verify the effectiveness of an educational model in learning a CC. The model must analyse the significance of a program of research competence (PCI) and learning by imitation of an expert researcher to reach scientific knowledge (CC) of undergraduate and postgraduate students, as applied to a prototype of the scientific method.

The purpose of the model was to achieve scientific knowledge (CC) in the novice researcher through the effect of connectivism (CO) mediated by individual learning (AI).

METHODOLOGY

The population consisted of 650 participants, and it comprised undergraduate students from the Faculties of Engineering, Health Sciences, and Management Sciences, and postgraduate students from the Master's program in Education and Public Management. A sample of 122 was selected using simple random stratified sampling and an error of .05. The research design was quasi-experimental with control and experimental groups.

It was determined that the experimental group would comprise students with better knowledge of the epistemology of the scientific method and its significance in creating research papers. In addition, they would have the author of this study as a tutor, while the control group would have a different tutor.

A pilot test was conducted to evaluate the comprehension of the instruments developed, including one that measured the initial CC of participants. The survey was conducted after the instruments were ready.

Only the students from the experimental group were trained in applying the educational model in 4 sessions that lasted 16 hours; they were also assisted by expert researchers who provided online comments on their experiences.

When this training ended, students took a knowledge test compared to the initial test, demonstrating their pre- and post-testing stages.

The educational model was evidenced by the effect of CO and AI on the CC and structured by a PCI that included vicarious learning, research phenomenon, and referential framework.

The *first one, or vicarious learning*, consists of imitating an expert researcher to accomplish CC. The *second one* considers the "introduction" component of the scientific method applied in a research study based on the experience of students using MOOCs**.**

The *third one*, *or referential framework*, is structured by: (a) empathy, (b) problem, (c) model, (d) solutions, and (e) evaluation.

The following were determined during the development of the introduction component:

(a) *Empathy* is defined as an activity to be conducted by the professor, which is placed in the task that students perform when they learn about the scientific method.

(b) The *problem*; it was considered that projects propose a question to be solved with different approaches or different questions proposing solutions with similar approaches.
(c) In the model, the first proposal was used, posing the question: how to overcome the CC deficiencies of novice researchers? In this regard, two solutions were used; the first, by considering the tutor's experience; and the second, by applying learning by imitation.
(d) As a *solution*, learning by imitation of an expert researcher was used, and a prototype with the following structure was developed:
    (*i*) problem statement, (*ii*) variables concept, (*iii*) definition of the background relevant to the research title, (*iv*) knowledge gap identification, (*v*) research question definition, (*vi*) solution proposals, (*vii*) justifications, (*viii*) objectives, and (*ix*) hypotheses.
(e) Finally, CC metacognition demonstrated the evaluation of the prototype by using two hypothesis tests: the path analysis with the presence of strong indicators and the simplified model by Hayes applying 10000 bootstrapping.

Three questionnaires were created to evidence the CO, AI, and CC: (a) the CO, comprised of 24 items and its neural, conceptual and external dimensions (AlDahdouh et al., 2015, p. 18); (b) the CC, comprised of 26 items and its active learning, research ability, and reflection dimensions (Somsak and Panita 2015, p. 2111); and (c) the AI, comprised of 39 items and its cognitive, metacognitive and affective dimensions. Furthermore, a Likert-type scale containing these categories was used: (1) =Does not know, (2) = Has little knowledge, (3) = Has moderate knowledge, (4) = Knows enough, and (5) = Has a fair amount of knowledge. After the information collected from the participants of both experimental and control groups was available, the data was filtered to avoid bias due to atypical data.

The questionnaires were validated by construct using Exploratory Factor Analysis (AFE), which is defined as a technique that correlates and reduces observed variables into latent variables or factors. The structure found by the AFE was corroborated by the Confirmatory Factor Analysis (AFC), as it offers the possibility of correcting a model while contrasting the hypothesis by covariance evidenced by the indicators that confirm the effective correlation between the theoretical and practical models. In other words, it is possible to verify if the model found as a result of the analysis of the sample units shows a good adjustment with respect to the model found and interpret the knowledge of one or more researchers who were in charge of studying the factors or variables identified in the study of a given phenomenon understood and exposed for knowledge.

Additionally, convergent validity techniques were applied, using factor loadings and discriminant validity, through the Average Variance Extracted (AVE).

In the questionnaire (AI), Bartlett's test of sphericity was found with: x^2= 4782.2, Gl= 528, *Sig.*= 0.000, proving the correlation between the items.

The KMO=0.962 statistic proved the non-existence of the identity matrix or satisfactory interrelationship. Factor loadings (λ) were greater than 0.760, evidencing factor satisfaction with coefficients ranging from 89% and 91%, correspondingly.

Its Average Variance Extracted (AVE) greater than 0.960 is highly acceptable (Hair et al., 1999), indicating that the cognitive, metacognitive, and affective constructs showed that over 96% of the variance was a function of their indicators. Its reliability obtained through Cronbach's alpha was .986, and the composite reliability was .970, as in Table 1.

In the questionnaire (CC), it was found that Barlett's test of sphericity had a coefficient of x^2= 3495, Gl= 325, and Sig.= 0.000, showing a correlation among the items.

The KMO=0.949 statistic proved the non-existence of the identity matrix or satisfactory interrelationship. Factor loadings (λ) were greater than 0.757, evidencing factor satisfaction with coefficients ranging from 86% to 98%. Its AVE was greater than 0.955, defined as highly acceptable (Hair et al., 1999), indicating that the constructs defined as active learning, research ability, and reflection showed that over 96% of the variance was a function of their indicators.

Reliability obtained with Cronbach's alpha was .969, and composite reliability was .963, as in Table 1.

TABLE 1
CONSTRUCT VALIDITY AND RELIABILITY OF CO, AI AND CC

Var.	Factors	Items	Validity		Reliability	
			Factor loading	AVE	Alpha	Composite
AI	Cognitive	18	.760 - .896	.927	.977	.947
	Metacognitive	9	.826 - .887	.867	.957	.900
	Affective	6	.874 - .907	.824	.955	.857
	Total	33		.960	.986	.970
CC	Active learning	8	.857 - .955	.870	.955	.889
	Research ability	11	.780 - .978	.897	.954	.918
	Reflection	7	.757 - .932	.848	.942	.874
	Total	26		.955	.969	.963
CO	Neural	6	.746 - 905	.808	.896	.857
	Conceptual	13	.785 - 917	.903	.953	.928
	External	5	.796 - .910	.791	.896	.833
	Total	24		.945	.969	.960

Note: This table shows the contribution of factor loadings of the CO on the CC mediated by the AI.

In the questionnaire (CO), Barlett's test of sphericity was x^2= 2523.9, Gl= 276, and Sig.= 0.000, showing a correlation among the items.

The KMO=0.944 statistic proved the non-existence of the identity matrix or satisfactory interrelationship. Factor loadings (λ) were greater than 0.746, corresponding to factor satisfaction with coefficients ranging from 75% to 92%.

Its AVE was greater than 0.945, which is defined as highly acceptable (Hair et al., 1999), indicating that the constructs active learning, research ability, and reflection showed that over 95% of the variance was a function of their indicators.

The reliability obtained with Cronbach's alpha was .969, while the composite reliability was .960, as in Table 1.

RESULTS

The results were classified into two parts. The first is analysing the difference in CC between the groups. Meanwhile, the second is testing hypotheses through a structural equation model with path analysis, and another using the modified simple mediation model by Hayes.

Group Difference

The students' scientific knowledge in the experimental and control groups differed in the pre-test and post-test stages.

The results obtained in the scientific knowledge test applied to the 66 participants of the control group showed a median of 98.06, while those of the 56 participants from the experimental group showed a value of 115.48. Both groups had statistically significant results.

Path Analysis

The theoretical model was subjected to a confirmatory factor analysis aimed to reproduce the matrix of polychoric correlations of the theoretical model by using, as an estimation method, unweighted least squares (Batista and Coenders, 2000) and measures of absolute, incremental, and parsimony fit.

The absolute fit compares the observed and implied models through a matrix of correlations or variances. In turn, the incremental fit establishes the comparisons between the proposed and base models.

Furthermore, the parsimony fit determines the model's goodness of fit in reference to its complexity (Hancock and Mueller, 2004).

In the research hypothesis test, first, the difference between groups was demonstrated, and then, the path analysis in Figure 1 confirmed the internal and external validity of CO, AI, and CC, ratifying the following hypotheses:

H1: *There is an effect of CO on AI*

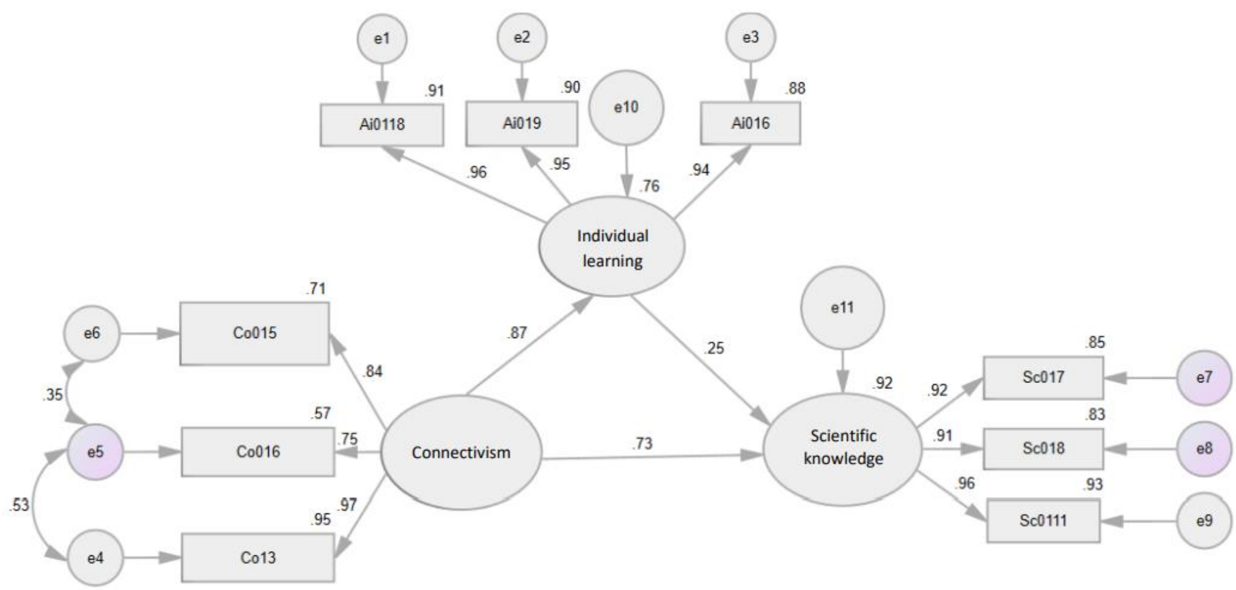
H2: *Effect of AI on CC*

H3: *Effect of CO on CC*

To prove H1, the path diagram shows an effect of 87%, and the factors with the best contribution are CO13 and CO015, or the conceptual and external aspects of the connectivist factor, with factor loadings of 97 and 82%, correspondingly.

As evidence of H2, the path diagram shows that the effect has a magnitude of 25%, and the factors with the best contribution are AI0118 and AI019, or the cognitive and metacognitive, presenting factor loadings of 96 and 95%, correspondingly.

FIGURE 1
PATH DIAGRAM OF THE EDUCATIONAL MODEL, THE CO, AI, AND CC FACTORS



Note. This graphic represents the effect of CO on the CC mediated by the AI.

H3, in the path diagram, shows a 73% effect of CO on the CC, with a magnitude of 0.73, and factors Sc0111 and Sc017, or research ability and reflection, with factor loadings of 96 and 92%, correspondingly.

Figure 1 also shows that all factor loadings of the indicators per factor are high. In the case of CO, the average is 0.85 in the AI = 0.91, and in the CC = 0.93. As for the fit indices, Wheaton (1977) defined the minimum discrepancy (χ^2/df) as optimal when the values are less than 5. In addition, Hu and Bentler (1999) and Kenny et al. (2015) stated that the Standardized Root Mean Square Residual (SRMR) should have values of less than 0.08, CFI, or TLI greater than 0.95. Furthermore, the allowed values of the RMSEA can be 0.05, 0.08, and 0.10 (Browne and Cudeck, 1993). The indices found show correspondence between the theoretical and practical models, with the presence of strong fit indices and correspondence between the constructs and the hypotheses.

The following were found among the indices: $\chi^2/df = 2.034$; SRMR = 0.0217; CFI = .983 or TLI = .973 and RMSEA = .092, showing a good fit of the model.

Modified Simple Mediation Model

Path analysis showed the influence of CO and AI on CC. To confirm this influence, the processes of the modified simple mediation model were applied, identifying direct and indirect values (Hayes, 2015).

For the application of the process, these variables were identified: *independent variable* "X= CO", *mediating variable* "M =AI" and *dependent variable* "Y= CC".

The influence of "X -- >M" resulted in the coefficient (*a*). In the case of the influence of "M >-- Y", the coefficient *(b)* was obtained. The influence of "X-->Y" resulted in (*c*) or total coefficient and (*c'*) or *direct effect*.

Finally, the *indirect effect* of "X --> Y" resulted in (*c*= *a***b*). Running the Macro Process program, these influences were found:

(1) "X--> M" with coefficient a = 1.17.
(2) "M--> Y" with coefficient b = 0.31.
(3) "X-- >Y" with coefficients c = 0.94 and c' = .363.

Each coefficient obtained a value of p = .000, indicating that they are statistically significant. Moreover, a value of 0.3610 was obtained for the indirect effect, running 10000 bootstrapping, with a confidence level of 95% which is statistically significant as the interval defined in the range [.1111 - 0.1691] does not register a zero value, evidencing the influence of CO on the CC mediated by AI.

DISCUSSION AND CONCLUSIONS

This study used the imitation of an expert researcher as a strategy based on the theory of vicarious learning through integrating an educational model complemented with a PIC. The result of this was that the CC of the 56 students in the experimental group was 16% greater compared to the 66 from the control group. In both groups, the "introduction" component of the scientific method was evaluated as a prototype.

The prototype was a theoretical resource and a practical demonstration of the educational model. This result confirms the accomplishment of the proposed objective, which established the relevance of an expert researcher in the understanding and explaining a phenomenon achieved by a novice researcher who evidences a gradual understanding of CC. In addition, it was found that the effect of CO on CC was 94% mediated on average by 95% of vicarious learning immersed in the components of cognitive and metacognitive learning and immersed in individual learning with impact on CC, particularly in its research ability and reflection components.

In the areas of health sciences and education, we found similar results. It is essential to consider that the purpose of the educational model is to be at the permanent service of those learning to conduct research since it is supported by the scientific method and the exchange of the application of CC. This can also be found in the research of Mourao and Bovolenta, (2018) who imply that CC must be built in the academic environment and in the interaction of society members who subsequently become active promoters of the building of CC.

The relationship between the researcher, the tutor, and the novice researcher characterizes this model. This interaction is based on the transmission of the researcher's experience in the politics and philosophy of a university and its laboratories.

Thus, information is provided regarding the syllabus, curriculum and didactics, promotion and development of innovation, knowledge of the epistemology of the scientific method, publications in high-impact journals, and intellectual property registration.

Moreover, publications of books in several publishing houses and networking by affinity through social media based on research fields.

Occasionally, tutors had frustrations while explaining to novices the development of unfamiliar topics or those outside their training and work experience. As a result, students find themselves amid uncertainty, sometimes receiving the support of an expert.

However, it must be considered that this person will not always be there to help them. This scenario follows the research of Ortiz-Lefort (2010), who proposed a multidimensional approach for researcher training processes to help them overcome the frustrations that may arise in interactions with students, organizations, or social participants.

In the study, the results in the CC of the control group participants were fairly satisfactory regarding the pedagogical research competence of the tutor.

Considering that the prototype is the beginning of a research study, its knowledge is presumed. In the experimental group, the participants reported improvements in understanding CC and a good level of research teaching competence of the tutor.

The experimental group's results follow the research of Perera et al. (2022) who verified the relationship between the educator's research teaching competence and the student's knowledge achievement.

In this sense, it is necessary to have integrative academic models that allow for building educational products collaboratively among educators and their students.

In the educational model, the effect of AI on CC is considered; however, the effect can be greater when, as part of the training, there are types of learning, such as ubiquitous, invisible, connectivist, and vicarious. Mastering these skills will probably result in the success of the novice researcher.

In the study, when the expert researcher evaluated the AI of the novices, many differences reflected in their CC were found, and it was deemed appropriate to improve them with theoretical support and application of the CO.

Here, there is a coincidence with the study by Yakhlef (2009) who, when studying knowledge, criticized the learning of the practical community, stating that the cognitive content and the learner's active role are neglected. Therefore, a student's participation in the school or social environment should not only serve to relate or belong to a community, but it must also build meaningful learning since it will ultimately be an important component of the research culture of the student.

In addition to the accomplishments attained by the novice researchers regarding CC and the coincidences with the studies that consider social interaction for building CC, multidimensionality in the training processes of researchers, availability of integrative academic models, the building of significant learning, it is also noted that the novice researchers showed an approach achieving their objectives. Therefore, a question arises: Why did some attain better results than others? One reason for this could be the difference in their AIs; the other could be the competence in the application of the educational model.

Still, strength in CC also depends on their knowledge of the scientific environment and the application of simulations to understand the world.

Yeo et al. (2021) obtained similar results when managers and technicians from the University of North Carolina at Chapel Hill from the United States implemented a PhD in Nursing at St. Luke's International University in Japan, thus improving the training of that Faculty.

Eaton et al. (2017) described the development of new nursing knowledge and evidence-based practice. Similarly, Valero et al. (2020) conducted an exchange of physicians from Brazil, Portugal, and Spain using CO and individual expertise. Furthermore, Badrinarayan (2022) proposed an educational process that facilitated the transmission of knowledge based on research through the theoretical teaching of organizational behaviour. Finally, similar research that allowed to attain knowledge of natural sciences was found (Shu-Jou, 2011; Yildirim and Bakırcı, 2021; Bakırcı et al., 2017).

During the development of this research paper, these limitations were found: results repetition, tutor assistance to the novice in a period deemed too short, extension of the prototype, and the application of a multiple linear regression model.

Results repetition; during the development of this study, "repeatability" was considered a fundamental condition of scientific production, and the results of the paper were the outcome of a single sample. To overcome this drawback, the bootstrap concept was used with the application of the simplified model by Hayes that simulates the process that would support the verification of results.

Tutor assistance to the novice; this part of the study began by identifying the experimental and control groups, in addition to the pre-test and post-test stages.

To begin with the pre-test stage, three instruments were developed as important components of the educational model and the PCI.

Subsequently, a training program was implemented for the experimental group using four sessions of four hours each for 16 hours.

It was determined that the subject to be developed would be the "introduction" component of the scientific method.

Knowing in advance that the support of the expert researcher would be available for only two face-to-face hours and that a MOOC would be used, both the group's training regarding the MOOC and the interventions of the expert researcher were in charge of the tutor during the four sessions.

When the training program ended, the CC of the groups was evaluated, finding improvements in 16% of the experimental group compared to the control group. The difference in the understanding of each group can be considered small; however, the difference in the training period among the groups was also small. This limitation in the training period was overcome with the development of a reference manual that allowed the novices of the experimental group to make online queries through mobile devices, computers, or written documentation of the components, searching for research titles, state-of-the-art, and thesauri according to the research topic.

This strategy allowed a reduction in the number of hours the novices spent consulting with the tutor, thus overcoming this limitation.

Extension of the prototype; the "introduction" component of the scientific method was selected as the prototype due to the time limitations of the expert researcher with the experimental group in the achievement of the CC of the novice. Although it dealt with its theoretical aspects, it represented the building of the reality of a researched phenomenon. The CC evaluation of the group revealed differences that might correspond to 0.16 of the total six main components of the scientific method considering introduction, theoretical framework, results, discussion, conclusions, and references. This difference demonstrates the model's effectiveness, and probably, upon developing the complementary components of the scientific method, it will be possible to reach its maximum percentage or get close to it.

Based on this analysis, it is suggested that other pieces of research could use the model to analyse the understanding of each component of the scientific method. In addition, it is suggested to establish the differences or difficulties found while differentiating the theory and empirics of the components, as one problem of the CC is understanding the phenomenon through the data, which is based on probabilities.

Application of a multiple linear regression model; the study was limited by the possibility of testing the hypothesis using three models; *first*, applying a multiple linear regression model, *second*, applying a structural equation model, and *third*, the simplified model by Hayes.

As for the first, this poses the need for reflection that arises when we try to prove a hypothesis in social science studies that identify independent and dependent variables. There is a possibility of finding qualitative-qualitative and ordinal variables in both, along with quantitative-quantitative variables and qualitative ordinal-quantitative variables. Moreover, the application of the model requires compliance with some assumptions, finding that they are met when there are quantitative-quantitative or qualitative-quantitative variables; however, it is different when dealing with an ordinal qualitative independent variable and similar in the dependent variable, forcing the assumptions recommended by statistical principles to be disregarded. Unfortunately, it is one of the most frequent in social science research.

On this matter, the literature revealed that a solution was found in applying the concepts of optimal scaling, which allows for overcoming the assumptions made by the statistical principles.

In categorical regression, the qualities or categories of the variables assign numbers to the categories that allow the optimal linear regression equation to be obtained for each transformed variable. This type of regression is known as categorical regression (CATREG).

It is suggested that other studies could use this type of regression to support a hypothesis with qualitative and categorical independent and dependent variables, which can be found in statistical analysis applications such as SPSS or other similar.

To conclude, there was evidence of the influence of the CO and AI on the CC, improving its understanding with the application of imitation or vicarious learning. In addition, there was sufficient evidence to guarantee the use of the educational model as a resource that can improve the scientific production of students. In that regard, it integrates theoretical and practical knowledge of a researched phenomenon based on the evidence of strong instruments due to their quality of validity and reliability.

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