Science Teaching at Primary Level based on BEME Methodology

Betsy Carol Cisneros-Chávez, Olga Melina Alejandro-Oviedo and
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Abstract--- *The main objective of this work was to measure the intervention of a methodological proposal of science teaching focused on the primary education level, which has four phases: information search, experimentation, measurement of results and scientific explanation. The intervention was adapted to the Flow Theory, during 8 months in 15 educational institutions with 343 students. The results obtained in comparison to before and after the intervention in the learning of the area of Science and Technology is 3.85 points for the median, considering the whole universe; likewise, there are favorable effects in the behavior of the learning, achievement of competencies and emphasis on the sense of homogeneity with respect to the achievement of the purpose of learning; 9 of the 15 institutions decreased the variance in the after and the parametric behavior was maintained; the other 6 go from nonparametric to parametric behavior, a result that provides a very important element in the learning of the curricular area, since BEME favors even more the cognitive deepening favoring above all the situational challenges that correspond to the experiences made with the BEME Scientific lunchboxes.*

Keywords--- *Science Teaching, Information Search, Experimentation, Results Measurement, Scientific Explanation, Loncheritas Científicas BEME.*

I. INTRODUCTION

An effective and efficient element of teaching thinking is to unlearn traditional practices in order to develop new ones with good results. According to Romero and Quesada (2014), learning science will show the potential of resources to build knowledge and take advantage of their formative value. Despite the epistemological advances of the different philosophical orientations on the nature of science, an abusive positivist orientation has prevailed in science teaching, which, in fact, in most cases, has excluded social, cultural or affective factors, even though they are didactically valuable, labeling them as improper or unscientific because they oppose the objectivity of science.

Numerous learning progressions appear in the literature in relation to science content learning, but fewer are related to didactic knowledge of science content, although they are considered to be of great importance for teacher training (Schneider y Plasman, 2011; Talanquer, 2014).

The teaching of science at the primary education level necessarily requires going through innovation processes that allow adapting pedagogical processes to relevant educational contexts (Villalba-Condori, García-Peñalvo, Lavonen, & Zapata-Ros, 2018), Tsybulsky (2018) researched the effectiveness of two methods of teaching biology based on the scientific research approach and the analysis of adapted primary literature; six weeks intervened with emphasis on five main aspects inherent to the nature of science: the temptation of scientific understanding, the

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scientific process and its cooperative nature, the methodological diversity, the socio-cultural integration of scientific knowledge and the objectives of scientific research obtaining results favorable to learning.

The most widely used methodologies in the context of science education - explored by Hurtado (2014), with presence in scientific articles - are project-based learning, discovery learning, cooperative learning, traditional methodology, problem-based learning, recreational-recreational methodology, research-based teaching, constructivist methodology, case method, competence-based teaching and comprehension teaching, which were obtained from 226 publications. In all cases defined roles for the teacher and student are established, as well as group interaction, further developing cooperative learning. (Tortosa, 2011).

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From the revised information, it is pertinent to mention the scarce interest and commitment to science learning from students (Osborne and Dillon, 2008) and to enhance or favour the attraction towards them, considering the inquiry approach to science teaching, which focuses on focusing, exploration, reflection and application, does not yet reflect the results it should provide, as we have before us the meagre results in PISA on Sciences. Despite the fact that the inquiry approach is based on the scientific method, it also requires that teachers have scientific skills that allow them to design and apply significant learning strategies that guarantee the achievement of learning in the classroom.(Reigosa, 2012).

The desire for permanent improvement in the teacher means that pedagogical knowledge can converge with the scientific discipline to be taught. In order to design what is called a school scientific activity (Izquierdo and Merino, 2009), the majority of teaching processes for the sciences reconstruct, link, facts and existing models that allow to explain other issues of interest. Structuring this scientific activity around theoretical models will allow recreating in the classroom a disciplinary knowledge that exists and that should only be taught as long as students are guaranteed to understand the functioning of the natural world that surrounds them (Adúriz-Bravo, 2010; Adúriz-Bravo y Izquierdo, 2009).

The importance of methodology in the teaching and learning process necessarily has two points of view; for example, those that incorporate active strategies in the traditional teaching methodology, such as playful participation, collaborative learning, continuous evaluation, use of ICT, formulating questions that arouse the curiosity of students, promoting interaction with students, among others, succeed in improving not only the motivation of students but also the quality of learning and their academic performance (Reyes y Gálvez, 2010; Del Vas, 2010; Martínez y García, 2011; Bausela, 2006; Diez, 2012).

The BEME method (Search for Information, Experimentation, Measurement of Results and Scientific Explanation) is governed by a methodological sequence that seeks to obtain reliable results through the monitoring of the four phases, with rigor and objectivity, using the BEME Lunchboxes (laboratory kit for classroom experiences).

BEME Method Phases

BEME's theoretical and methodological support in the investigative approach to science teaching is considered.

a. Searching for information

The first stage of the process has the objective to generate in the student interest, expectation and evocation of their previous knowledge. These previous ideas require a certain process of investigation, because they cannot be simply constructions of the moment; they are the starting point for experimentation. It is the moment when information is provided from the pedagogical point of view when some concepts are approached.

This stage begins with the collection of information through the application of human senses: *see, hear, touch, taste and smell*. In this phase, children are encouraged to ask questions, conduct research, and make their own discoveries.

For this, the teacher must use an attractive question, based on a situation and/or context where the phenomenon to be investigated intervenes. By means of an appropriate guide, the student's curiosity is encouraged and he or she expresses it in a question. In Antúnez's words (2007): "Classroom work should always be posed as a proposition of problems, curious questions, surprising contextualizations, suggestions of challenges, stimuli to deductions built on clues offered".

In the investigative process this part is considered as the generation of the hypothesis where the subject evaluates his knowledge in order to give a possible answer to a question in order to verify it later.

b. Experimentation

In this stage the experimental material of the Scientific Lunchboxes BEME is manipulated in order to extract and record data that will lead the student to interpret and understand the phenomenon to be studied.

The development of the stage is done in a group way so that, through dialogue, students share ideas. The following has been considered as the activity proposed in this way regarding experimentation:

- For the development of experimentation, permanent advice from the teacher, who is always attentive to the needs and interests of students.
- Scaffolding among students, who plan ways to investigate or demonstrate their hypotheses; for this, there must be a high level of autonomy in the development of the process for experimentation.

c. Results measurement

The first step is the data recording that was defined in the previous stage; this recording is done based on the hypothesis raised; the student outlines and interprets the data he collects. This stage is one of the most important, since without data collected it will not be possible to move on to the next phase.

d. Scientific Explanation

This stage allows to extend the acquired knowledge applying it in other fields or in the same one, with the purpose of developing the studied phenomenon in other situations and/or contexts where its presence influences; this allows to give a greater depth and amplitude to the understanding of a phenomenon. For the execution of this stage, having already fulfilled the others, a different situation is suggested by means of the presentation of one or several images, circumstance in which, by means of a question or statement, the student applies and explains his knowledge in a different situation.

La descripción del experimento y el registro de observaciones deben darse en lenguaje científico, convenientemente suplementado con terminología técnica. Esta es una clara exigencia lógica, ya que la palabra "experimento" se refiere a una situación en la que se puede decir a otros qué es lo que se ha hecho y qué es lo que se ha aprendido.

La fig. 1 muestra las fases y subfases de BEME, es secuencial después de la primera fase, sin embargo las subfases no necesariamente son secuenciales.

The experiment description and the observation record should be given in scientific language, conveniently supplemented with technical terminology. This is a clear logical requirement, since the word "experiment" refers to a situation in which one can tell others what has been done and what has been learned.

Fig. 1 shows the BEME phases and subphases, it is sequential after the first phase, however the subphases are not necessarily sequential.

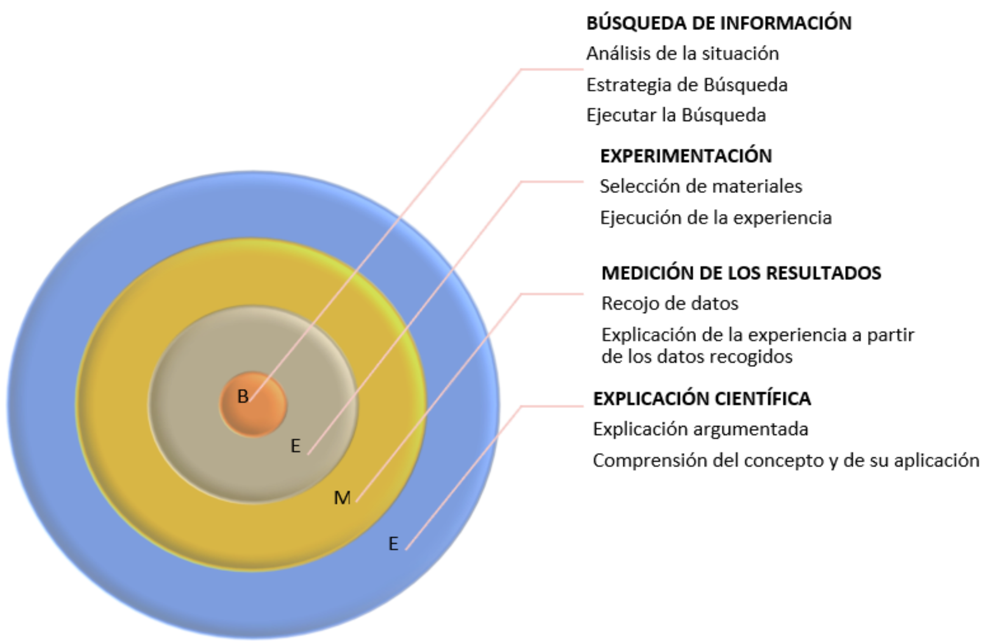

Figure 1: BEME phases and subphases

BEME's application is made with the intention of identifying the aspects that can be improved and that are part of this methodology. In view of this, the following procedures for intervention were considered:

A test was prepared that was previously validated with the intervention of ten experts in the area teaching; here three sample applications were carried out until obtaining the acceptable level of reliability considering the competences corresponding to the fourth grade of primary education of the Primary Curricular Design.

Then, the process of strengthening the scientific competences and skills of the teachers of the 15 educational institutions in which they intervened was carried out, in addition to the respective accompaniment, which was carried out on a weekly basis to ensure the adequate application of the BEME methodology.

Situational engagement was contextualized to the Flow Theory (Schneider, Krajcik, Lavonen, et. Al, 2015), to ensure specific situational interest in the content and context of the task, which depends on knowledge, values and feelings (interest). Appropriate activities were prepared for the fourth grade of primary education; in other words, care was taken to anticipate situational resources (skills) and finally to guarantee the demand for situational tasks, i.e., to infuse students with high levels of challenge and the desire to persist in a science learning situation (situational challenges).

II. RESULTS

From the 343 students who were part of the research, the following behaviors are recurrent:

- Active participation in the acquisition of knowledge, through research and curiosity
- Search for truth, information or knowledge
- Collaborative work
- Controlled experimentation
- Development of critical thinking and the ability to solve problems by improving skills, attitudes and scientific reasoning
- Development of a scientific language with which students express the results of their research through a series of scientific concepts that they have tested and internalized.

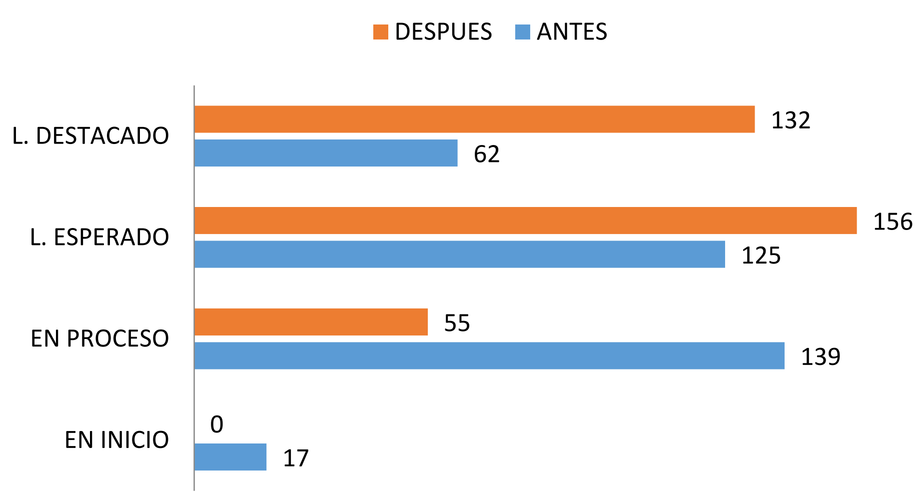

Figure 2: BEME intervention analysis

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Figure 2 shows the effectiveness of BEME in achieving substantial changes in the learning of the Science and Technology Curricular Area in the BEFORE (remember that before and after was measured) and shows the global variations respect to the categorization of academic performance.

It was observed that after eight months there is a large increase in the outstanding and expected achievement, which according to the evaluation criteria of the Ministry of Education would correspond to the highest levels of performance. In the case of the Start and Process criteria, there was a sharp decrease; and in order to corroborate these results, the sampling experience was measured in the sessions with BEME:

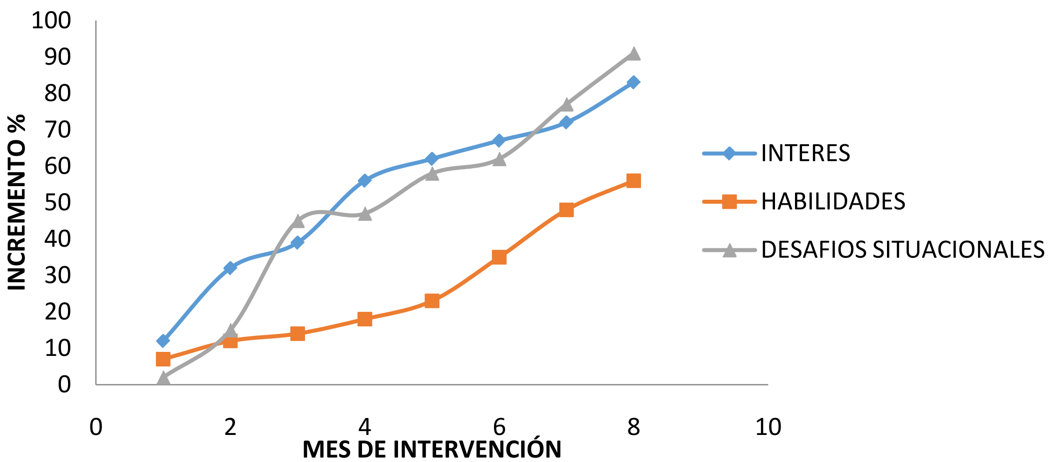

Figure 3: Experience sampling measurement (ESM)

In order to adapt BEME's situational context to the Flow Theory, we observed a gradual increase in the three aspects measured (short surveys that were applied after each session with BEME). For the Skills aspect, there is a positive correlation in the management of scientific skills of teachers with those of students; the aspect of situational challenge interest is the one that shows the greatest percentage growth, as the research was developed. This precedent is very relevant because BEME was designed to achieve that approach in the student.

Finally, a statistical analysis was carried out to show the differences found between before and after the intervention; for this purpose, a normal data analysis was carried out, finding for the Kolmogorov-Smirnov test in the Pre or before the intervention a significance of less than 5% in the same way as in the Post; on the basis of these results it is concluded that the data behavior is NOT PARAMETRIC, that is, its behavior in the before and after the intervention as a whole is heterogeneous; This is why the Wilcoxon test was chosen, obtaining a value less than 5% for the p value, which indicates that there are differences in the after with respect to the before the intervention; due to the nature of the analysis, it is appropriate to compare medians whose value was 3.85 points; this analysis is the global one, that is to say, it corresponds to the 343 students of the 15 Educational Institutions.

In the case of the standard deviation, the difference between the means is so great that it is not possible to consider them and neither is it possible to distinguish a clear trend due to the standard deviation of the group in each of the items.

From the results obtained and from the normality test carried out to see the behaviour of the data, the Wilcoxon test is chosen, obtaining a p value less than 0.05, which allows us to accept the alternate hypothesis indicating that there are differences. We found that because this type of statistical test, the measure of central tendency to compare is that of the Medianas, giving a 3.85 difference from the before-after.

III. Discussion And Conclusions

Science is considered today as a human practice that aims to give meaning to the world around us. To do this, we develop a series of theoretical ideas based on evidence and the verification of facts, avoiding subjective aspects that condition our perception of what surrounds us. In this sense, the present study takes as base the conception that science is composed of ideas and knowledge product of years of discoveries and that they are the support for the development of abilities and ways of thinking by means of which this knowledge is constructed (DeBoer, 1991).

The principle of Flow Theory is based on the idea that an activity carried out in a state of intense concentration will allow the subject to develop it again for pure pleasure, even if the activity is difficult to carry out. The formality with which science is usually taught in school has only made it conceive as a complex subject. This is the reason that has led researchers to propose a program focused on the work of the child to enter into the real and experiential learning of science.

The BEME method is based on a set of methodological processes that allow us to find answers following the steps of the scientific method. The child learns in context, which becomes an effective and efficient element of teaching to think. Learning in an experiential way allows to unlearn traditional practices in order to develop new practices with good results. The learning of the sciences will allow, then, to show the potential of the resources for the construction of knowledge and to take advantage of the formative value of the same ones (Romero y Quezada, 2014).

The results of this study show an active participation in the knowledge acquisition, through research and curiosity. These two elements are developed through the search for truth, information or knowledge; collaborative work; controlled experimentation; the development of critical thinking and the ability to solve problems by improving skills, attitudes and scientific reasoning. To these results must also be added the development of a scientific language with which students express the results of their research through a series of scientific concepts that they have tested and internalized.

Another result to highlight is the positive correlation that exists between the management of scientific skills of teachers with that of students, an important precedent because the BEME program was designed to achieve that approach in the student. On the other hand, there are differences between before and after the application of the program. Significance indicates a value less than 5% in the same way as in the Post. Based on these results we affirm that the behavior is NOT PARAMETERIC, that is to say, that, in a global way, its behavior is heterogeneous before and after the intervention.

To conclude, scientific practices were, in general, more attractive than other situations in science class. While it is true that no comparison was made with control groups, the positive increase represents how the use of BEME influences the process of teaching and learning. Participation in Situational Challenges and Interests increased month by month; in the case of skills, it does not have the same impact as in the other two aspects, which may be due to the fact that in the last months of the application the accompaniment was carried out, but not the training of teachers, that is to say, that teachers need to strengthen their scientific competencies even more.

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REFERENCES

[1] Adúriz-Bravo, a. (2010). Hacia una didáctica de las ciencias experimentales basadas en modelos. II Congrés en Internacional de DIDACTIQUES 2010. Retrievedfromhttps://core.ac.uk/download/pdf/132550040.pdf

[2] Adúriz-Bravo, a. y Izquierdo, m. (2009). Un modelo científico para la enseñanza de las ciencias naturales. *Revista electrónica de investigación en educación en ciencias*, 1, 40-44.

[3] Antúnez, S. (2007). El cuidado de los procesos de transición de primaria a secundaria a modo de balance. *Revista Aula de Innovación Educativa*, 142, 23-30.

[4] Aymerich, M. y Merino, C. (2009). Los modelos en la enseñanza de la química. *Enseñanza de las Ciencias*, Número Extra VIII Congreso Internacional sobre Investigación en Didáctica de las Ciencias, 3477-3479

[5] Bausela, E. (2006). Nuevas claves para la docencia universitaria en el Espacio Europeo de Educación Superior. *Revista de Enseñanza Universitaria*, 27, 103-104.

[6] Deboer, G. (1991). *A History of Ideas in Science Education*. New York: Teachers College Press.

[7] Del Vas, J. (2010). Metodologías activas en la enseñanza universitaria, innovación educativa en derecho constitucional, recursos, reflexiones y experiencias de los docentes. Universidad Católica San Antonio de Murcia. Recuperado de http://www.doredin. mec.es/documentos/01520113000452.pdf.

[8] Diez, E. (2012). Modelos socio constructivistas y colaborativos en el uso de las TIC en la formación inicial del profesorado. *Revista de Educación*, 358, 175-196.

[9] Hurtado, G. E. (2014). ¿Cuáles son las tendencias en las metodologías de enseñanza de la última década en Iberoamérica?-¿Which are thetrends in the teaching methods of the past decade in Iberoamérica? *Revista Científica*, *1*(18), 86-99. https://doi.org/10.14483/23448350.5564

[10] Izquierdo, M, y Merino, C. (2009). Modelos en la enseñanza de la Química. *Enseñanza de las ciencias: revista de investigaciòn y experiencias didàcticas*, Número Extra VIII Congreso Internacional sobre Investigación en Didáctica de las Ciencias, 3477-3479

[11] Jiménez, R. y De Manuel, E. (2009). La química cotidiana, una oportunidad para el desarrollo profesional del profesorado. *Revista Electrónica de Enseñanza de las Ciencias, 8*(3). 878-900.

[12] López, G. (2011). Empleo de metodologías activas de enseñanza para el aprendizaje de la Química. *Revista de Enseñanza Universitaria*, 37, 13-22.

[13] Martínez, M. y García, A. (2011). ¿Cómo cambian las estrategias de aprendizaje de los estudiantes universitarios con la adaptación metodológica al espacio europeo de educación superior? *Bordón Revista de Pedagogía, 63*(2), 65-74.

[14] Osborne, J. y Dillon, J. (2008). *Science education in Europe: Critical reflections*. London: The Nuffield Foundation.

[15] Reigosa, C. (2012). Un estudio de caso sobre la comunicación entre estudiantes en el laboratorio escolar. *Revista Electrónica de Enseñanza de las Ciencias, 11*(1), 98-119.

[16] Reyes, E. y Gálvez, J. (2010). Experiencias docents en innovaciòneducative como mejora de una neseñanza tradicional de los materiales de construcción. *Formación universitaria, 3*(4), 13-24.

[17] Rodríguez, A., González, P., Malonda, J., Gutiérrez, I., De La Fuente, E., D. y Olmos, J. (2004). Los trabajos complementarios de asignatura en la formación de los maestros: una perspectiva constructivista e interdisciplinar. *Bordón revista de pedagogía, 56*(2), 347-364.

[18] Romero, M. y Quesada, A. (2014). Nuevas Tecnologías y aprendizaje significativo de las ciencias. *Enseñanazas de las ciencias, 32*(1), 101-115.

[19] Schneider, R. y Plasman, K. (2011). Science Teacher Learning Progressions: A Review of Science Teachers' Pedagogical Content Knowledge Developmen. *Review of Educational Research*, *81*(4), 530–565.

[20] Schneider, b., Krajcik, j., Lavonen, j. m. j., Salmela-aro, j. k., Broda, m., Spicer, j., Bruner, j., Moeller, j., Inkinen, s. j. m., Juuti, k. p. t. &Viljaranta, j. H. (2015). Investigating optimal learning moments in US and Finnish science classes. Journal of Research in Science Teaching, 53, 400–421.

[21] Talanquer, V. (2014). DBER and STEM education reform: Are we up to the challenge? *Journal of Research in Science Teaching*, *51*(6), 809-819.

[22] Tortosa, M. y Gorchs, R. (2011). Análisis de las prácticas de química de futuros ingenieros: propuestas de mejora efectivas en el marco del Espacio Europeo de Educación Superior. *Revista electrónica de enseñanza de las ciencias*, *10*(3), 531-549.

[23] Tsybulsky, D. (2018). Comparación de impacto de dos métodos de investigación científica en la comprensión de NOS de estudiantes de biología de escuela secundaria. *Revista* , *27*(7), 661-683. DOI: 10.1007 / s11191-018-0001-0

[24] Villalba-Condori, K. O., García-Peñalvo, F. J., Lavonen, J., & Zapata-ros, M. (2019). What kinds of innovations do we need in education?. In Villalba-Condori, K. O., García-Peñalvo, F. J., Lavonen, J., & Zapata-Ros, M. (Eds.), proceedings of The II Congreso Internacional de tendencias e Innovación Educativa - CITIE 2018, (Arequipa, Perú, November26-30, 2018) (pp.9-15). Aachen, Germany: CEUR-WS.org.